BRITISH COLUMBIA HYDRO & POWER AUTHORITY

HAT CREEK PROJECT

1979 ENVIRONMENTAL FIELD PROGRAMMES

THERMAL GENERATION PROJECTS DIVISION

APRIL 1981

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1.0 INTRODUCTION

Numerous environmental studies related to the proposed Hat Creek thermal powerplant development have been conducted over the past four years to define environmental conditions in the region. Some of these studies have been continued to provide more detailed background data. Those carried out during 1979 at the Hat Creek site include the following:

- meteorological, air quality, surface water and ground water monitoring programmes to better define existing conditions;
- leachate studies to assess long term characteristics of leachate from waste coal materials;
- trace element studies to better define and document existing natural levels in the region.

During 1977 a reclamation test programme was initiated using waste materials from the Bulk Sample Programme. These reclamation tests were designed to assess on a large scale the revegetation potential of various coal waste and overburden materials and to evaluate other variables pertinent to the successful revegetation of these waste materials. The preparation of test plots and the initial planting was carried out in 1977. The success of the reclamation programme after one year's growth was assessed during 1978 and modifications were made to improve the reclamation where necessary and to evaluate additional variables. In 1979 the results of the reclamation test programme were assessed and further improvements were made to the test programme.

The exploration drilling programme which started in 1974 was completed in 1978 and reclamation of all the drill sites was also completed in 1978. During 1979, the success of the drill site reclamation programme was evaluated.

This report presents the results of these environmental study programmes carried out during 1979. Data from previous years are also presented and compared to the 1979 results.

2.0 REVEGETATION PROGRAMMES

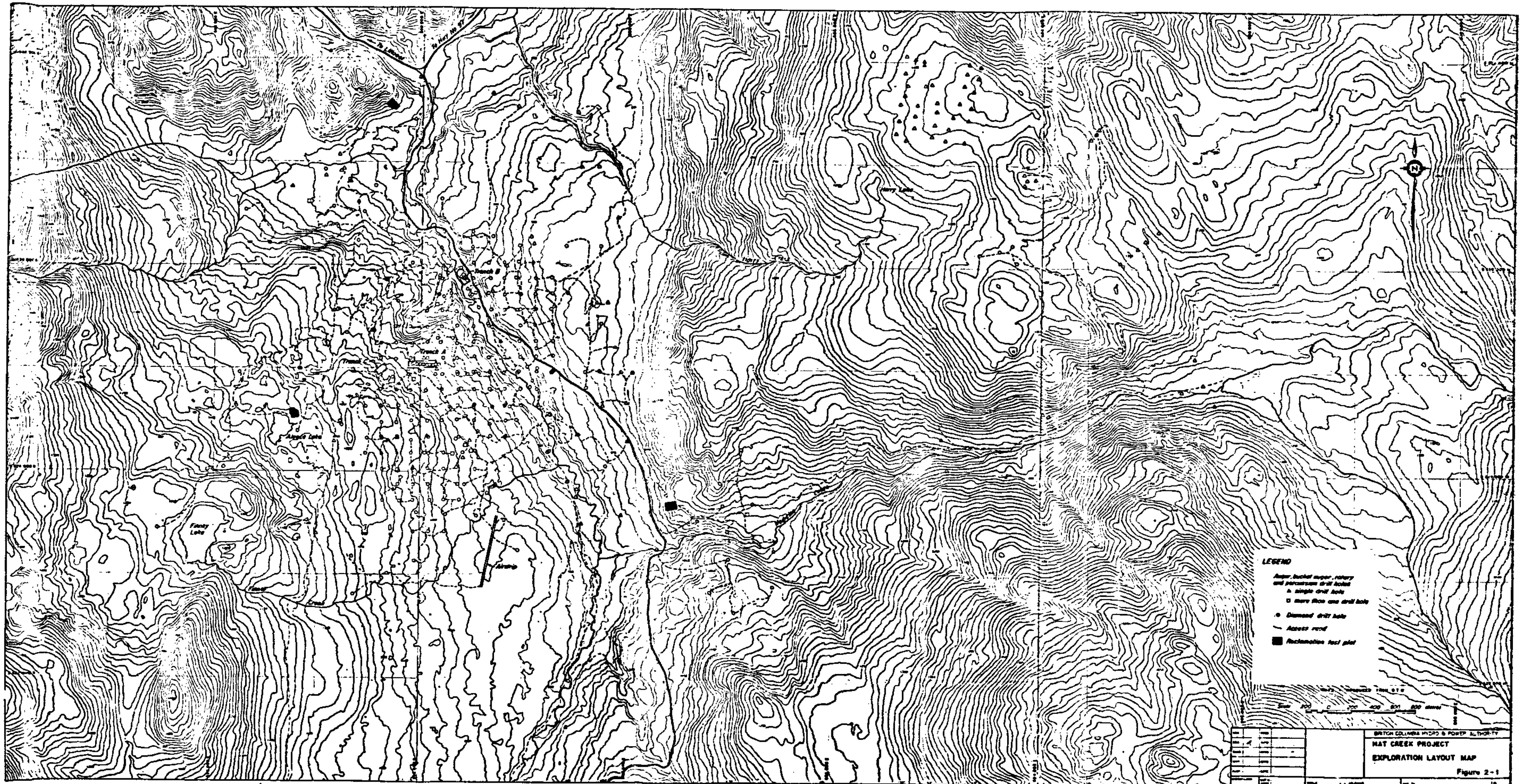
2.1 Introduction

Land disturbances at Hat Creek have resulted from exploration drilling, access road development and from the excavation of three test trenches. The exploration drilling programme and construction of access roads was initiated in 1974 and completed in 1978. The excavation of the test trenches occurred during 1977 as part of the Bulk Sample Program. Reclamation of these disturbances was commenced in 1974 and is continuing. Special revegetation test plots were set up in 1977 using overburden and coal waste materials obtained during the Bulk Sample Program. The locations of the disturbed areas and the prepared test plots are shown in Fig. 2-1. The 1979 revegetation programmes included the following:

- Continued monitoring of the eight test plots at Aleece Lake to evaluate a wide variety of vegetation species potentially useful at Hat Creek in combination with the various waste materials expected from mine and powerplant.

- Monitoring of the slope test plots at Houth Meadows and Medicine Creek to determine the revegetation potential of different slopes.

- Monitoring of the 1977 Bulk Sample Program waste dumps at Trenches A, B and C which were seeded and are being used to gain data on different seeding methods, surface treatments and maintenance fertilizer requirements.


LEGEND
Auger, bucket auger, rotary and percussion drill holes
single drill hole
more than one drill hole
Diamond drill hole
Access road
Reclamation test plot
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EXPLORATION LAYOUT MAP
Figure 2-1

- Monitoring of revegetated drill sites.

This section summarises the procedures and the results of these monitoring programmes which were carried out during 1979 to assess the progress of the various reclamation studies at Hat Creek.

2.2 Soils Analyses and Fertilizer Additions

Introduction

During the 1977 Bulk Sample Program[1], the waste materials were analysed for nutrients and the results used to determine fertilizer addition during initial seeding. Soil materials at Aleece Lake, Houth Meadows and the slope test plots at Medicine Creek were again sampled and analysed during April 1978. Based on these results, maintenance fertilizer additions were made to the Aleece Lake test plots[2].

In March 1979, the waste materials being revegetated at Hat Creek were sampled and analysed to further characterise the soil properties. Maintenance fertilizer additions were made to all areas and a 5-year programme was initiated to determine long-term fertilizer requirements on waste materials at Trench A (baked clay and gritstone), Trench B (gravel), Trench C (bentonitic clay) and Houth Meadows (colluvium).

A detailed assessment of all Hat Creek soils data, to describe the waste materials and relate the soils properties to the results of revegetation trials, was commenced in 1979 and will be completed in 1980. The preliminary results of this detailed assessment are summarised in this section.

Methods

All samples were taken as described in the 1978 report[2]. The soil was first loosened to a depth of approximately 20 cm with a shovel blade and sampled along the untouched surface with a heavy plastic scoop. At least four samples were taken from each soil material, composited, thoroughly mixed, placed in plastic bags and shipped to the Soil Testing Laboratory of the B.C. Department of Agriculture (BCDA) in Kelowna, B.C. Following standard soil analyses the samples were sent to the Ministry of the Environment laboratory in Kelowna for further analyses. Test methods used are as described in the report by Acres[3] and by Black[4].

Results

Results of all tests on Hat Creek soils taken in 1977, 1978 and 1979 are shown on Table 2-1. The report from the BCDA laboratory in Kelowna recommended fertilizer additions, based on the 1979 soils tests, to be applied for good growth of a grass and legume crop. The amounts of fertilizers added to the various test plots in 1979 are shown in Table 2-2.

Fertilizer was applied to all the Aleece Lake plots, the slope test plots, the 3160 dump and coaly waste pile at Trench A and the topsoil and subsoil piles at Trench B. In addition to the fertilizer, the following three areas at Trench A received applications of lime at the rate of 2242 kg/ha: a 15m x 15m plot on the coaly waste dump and plots of 23m x 10m and 35m x 20m on the non-topsoiled portion of the 3160 dump.

TABLE 2-1 RESULTS OF HAT CREEK SOILS ANALYSES

	SURFICIAL SOILS									
	TOPSOIL					COLLUVIUM				
Location	Trench A	Trench A	Trench B	Trench B	Houth Mead.	Trench A	Aleece Lake	Aleece Lake	Houth Mead.	Houth Mead.
Sample Date	Jul 77	Mar 79	Jul 77	Mar 79	Apr 78	Jul 77	Apr 78	Mar 79	Apr 78	Mar 79
Texture <2.00mm %	73.9(1)	75.5(5)	94.4(1)	85.8(5)		61.4(1)		67.8(5)		66.5(5)
CSSS Tex Class (3)	CL	CL	Loam	SiL		SCL		CL		Loam
% Sand (2)	31.9	26.33	42.5	21.38		47.6		28.91		46.05
% Silt (2)	39.2	34.9	35.	52.82		20.8		36.22		37.44
% Clay (2)	28.9	38.77	22.5	25.80		31.6		34.87		16.51
BCDA Tex-Feel (1)	3	4	3	4	3	5	4	5	5	5
Organic Matter (%) (1)	7.0	8.3	3.9(1)	3.7	3.6	0.6	3.0	4.7	1.1	1.1
pH (units) 1:2 Soil/Water; 1:1 Soil/Water; 1:2 Soil/CaCl2; Sat. Extr.	7.4 7.45 7.11	7.4(1)(2)	7.1 7.87 7.35	8.1(1)(2)	8.3(1)	8.7 8.4 8.4 7.8	7.9(1)	7.7(1)(2)	8.0(1)	8.5(1)(2)
Conductivity mmhos/cm Saturated Extract. (1)(2)(3)	.6 1.39	.82 1.95	.4 .83	.28 .48	.34	6.00 10.3 9.2	3.50	3.10 3.62	.32	.26 .48
Available Nutrients (1)										
NO_3 - N (lb/2x10^6 lb)	15	55	36	13	9	31	19	5	4	2
P	40	17	29	43	89	7	56	74	5	5
K	939	706	493	503	474	216	563	518	223	247
Ca	10000+	10000+	9795	10000+	10000+	9927	10000+	10000+	9117	9161
Mg	1000+	1000+	1000+	1000+	1000+	1000+	1000+	1000+	1000+	1000+
Na ppm		49		39	30		140	109	20	24
S Sulphate ppm	30+	30+	13.4	20.2	2.9	30+	30+	30+	2.3	30+
B H_2O curcumin-oxalic ppm		.56		.37	.46		.30	1.34	.38	.26
Cation Exchange (2)(3)(5)										
C.E.C. meq/100g	40.79	46.89	29.24	31.03		9.37		37.58		9.67
% Base Sat.	100+	100+	100	100+		100+		100+		100+
Σ Bases. meq/100g	53.05	55.54	38.73	38.24		46.12		55.56		21.99
Ca meq/100g	37.50	42.93	30.36	30.68		32.71		41.96		18.35
Mg meq/100g	13.31	11.05	7.25	6.57		11.84		12.43		3.24
Na meq/100g	.27	0.36	.34	0.28		1.29		0.19		.11
K meq/100g	1.97	1.20	.78	.71		0.28		0.98		.29
Exchangeable Sodium %	0.7	0.768	1.2	0.902		13.8		0.506		1.14
Dissolved Anions & Cations (2)(3)(5)										
HCO_3^- meq/100g		nc		nc		33×10^{-3}		nc		nc
meq/litre		1.8		2.7				4.07		2.0
$CO_3^=$ meq/100g		nc		nc				nc		.1
meq/litre		0		0				0		
Cl^- meq/100g	.020		.019			.077		nc		
meq/litre		1.3		0.76				4.7		1.03
meq/100g						0.19				
SO_4 meq/100g						3.6				
sat. ext. meq/litre		30.0		0.6						11.8
1:5 s/w ext meq/litre (2)								17.9		
B meq/100g	nc		nc			$<2.7\times10^{-4}$				
ppm	.44		.6			1.91				
Ca meq/100g		1.21		0.23		.042		1.84		0.114
meq/litre		16.97		3.54		2.15		31.49		3.74
ppm		340		71				611		75
Mg meq/100g		0.45		0.07		1.83		1.39		0.078
meq/litre		6.34		1.15		94.65		23.05		2.55
ppm		77		14				280		31
Na meq/100g		0.01		0.05		0.58		0.45		0.034
meq/litre		1.39		.78		29.21		7.39		1.13
ppm		32		18				170		26
K meq/100g		.04		0.02		.009		0.06		.01
meq/litre		.59		.28		nc		1.02		.31
ppm		23		11				40		12
Sodium Adsorption Ratio (5)		.41		.51		4.20		1.43		0.64
Water Content at Saturation (2) Wt % g H2O / g soil(dry)		71.48		63.66				60.46		30.47

	SURFICIAL SOILS										
	TILL			GRAVELS							
Location	Med. Crk.	Med. Crk.	Med. Crk.	Aleece Lake (Glacial)			Trench B (recent)			Houth Meadow (recent)	
Sample Date	Jul 77	Apr 78	Mar 79	Jul 77	Apr 78	Mar 79	Jul 77	Apr 78	Mar 79	Apr 78	Mar 79
Texture <2.00mm %	58.4(1)		[illegible](5)	32.4(1)		35.5(5)	22.1(1)		42.5(5)		[illegible](5)
CSSS Tex Class (3)	Loam		SCL	SiL		SCL	SL		SL		Loam
% Sand (2)	49.4		46.79	31.7		52.13	74.7		60.09		39.84
% Silt (2)	28.7		27.18	60.9		26.23	19.2		27.22		45.50
% Clay (2)	21.9		26.03	7.4		21.64	6.1		12.69		14.66
BCDA Tex-Feel (1)	5	4	5	2	4	2	1		2	2	2
Organic Matter (%) (1)	1.2	1.6	1.9	1.7	2.0	2.4	.9		2.6	2.5	1.5(5)
pH (units) 1:2 Soil/Water; 1:1 Soil/Water; 1:2 Soil/CaCl2; Sat. Extr.	8.0 8.75 7.65 7.5	8.4(1)	8.2(1)(2)	8.0 8.06 7.66 7.7	8.5(1)	8.5(1)(2)	8.1 8.28 7.48 8.1		7.9(1)(2)	7.9(1)	8.0(1)(2)
Conductivity mmhos/cm Saturated Extract. (1)(2)(3)	.32 <1.0 .605	0.44	0.26 .42	.48 1.61 .952	.56	.30 .62	.24 .76 .412		.26	.74	.24 .78
Available Nutrients (1)											
NO_3 - N (lb/2x10^6 lb)	2	26	6	5	47	8	4		2	33	7
P	10	101	104	11	71	100	17		32	113	104
K	346	552	537	378	452	465	195		319	247	324
Ca	8221	10000+	10000+	8926	10000+	9801	5344		6566	8207	9051
Mg	1000+	1000+	633	1000+	1000+	1000+	655		749	958	1000+
Na ppm		20	6		50	34			38	40	33
S Sulphate ppm	19.4	5.3	30+	30+	5	30+	10.6		14.1	30+	26.4
B H_2O curcumin-oxalic ppm		.53	.20		.38	.86			.49	.2>	.2
Cation Exchange (2)(3)(5)											
C.E.C. meq/100g	13.04		19.18	16.38		21.83	11.14		15.7		17.9
% Base Sat.	100+		100+	100+		100+	100+		100+		100+
Σ Bases. meq/100g	25.98		27.11	32.62		32.79	15.43		19.87		23.20
Ca meq/100g	20.40		23.73	25.64		25.94	12.22		16.39		19.35
Mg meq/100g	4.93		2.54	6.09		5.99	2.70		2.97		3.31
Na meq/100g	.23		0.05	.35		0.10	.23		.18		.16
K meq/100g	.42		.77	.54		.76	.28		.33		.38
Exchangeable Sodium %	1.8		0.26	2.1		0.458	2.1		1.1		0.9
Dissolved Anions & Cations (2)(3)(5)											
HCO_3^- meq/100g	75.6×10^{-3}		nc	nd		nc			nc		nc
meq/litre			2.3			2.5			2.6		2.0
$CO_3^=$ meq/100g	0		0	nd					nd		0
meq/litre	0		0			0					
Cl^- meq/100g	0.016			.015		nc	.007		nc		
meq/litre			.9			2.13			.76		.94
meq/100g	.01			.009			.005				
SO_4 meq/100g	.54			.26			.009				
sat. ext. meq/litre			.40			2.0					1.2
1:5 s/w ext meq/litre (2)									.9		
B meq/100g	3.9×10^{-4}			1.5×10^{-4}			7.2×10^{-4}				
ppm	.14			.12			.26				
Ca meq/100g	.117		0.145	.163		0.14	.060		.13		.09
meq/litre	3.87		3.34	6.19		3.19	2.2		5.29		3.24
ppm			67(2)			64			106		65
Mg meq/100g	.059		0.029	.106		0.062	.022		.05		.03
meq/litre	1.96		.66	3.91		1.40	1.03		2.06		1.07
ppm			8(2)			17			25		13
Na meq/100g	.038		.0095	.047		0.0899	.015		.025		.03
meq/litre	1.25		.22	1.71		2.04	.7		1.04		1.22
ppm			5			47			24		28
K meq/100g	.005		.018	.003		.017	.007		.09		.005
meq/litre	nc		.41	nc		.38	nc		.36		.18
ppm			16			15			14		7
Sodium Adsorption Ratio (5)	0.73		0.16	0.76		1.35	0.55		.54		0.83
Water Content at Saturation (2) Wt % g H2O / g soil(dry)			43.37			44.06			24.33		28.60

	SURFICIAL SOILS				NON-SEAM WASTE							
	BAKED CLAY				BENTONITIC CLAY				GRITSTONE (sandstone, claystone)			
Location	Trench A	Aleece Lake 3140'	Aleece Lake	Aleece Lake	Trench A	Trench C	Aleece Lake	Aleece Lake	Trench A	Trench A	Aleece Lake	Aleece Lake
Sample Date	Mar 79	Jul 77	Apr 78	Mar 79	Jul 77	Mar 79	Apr 78	Mar 79	Jul 77	Mar 79	Apr 78	Mar 79
Texture <2.00mm %	51.4(5)	55.9(1)		50.5(5)		73.1(5)		60.4(5)	96.4(1)	62.5(5)		91.2(5)
CSSS Tex Class (3)	SL	SL		SCL	Clay	Clay		Clay	Loam	CL		SiCL
% Sand (2)	54.40	49.9		54.01	21.9	22.78		22.46	43.5	26.85		17.37
% Silt (2)	26.25	43.9		25.87	33.7	29.24		29.62	33.0	39.56		46.77
% Clay (2)	19.35	6.2		20.12	44.4	47.98		47.92	23.5	33.59		35.86
BCDA Tex-Feel (1)	2	2	2	4	5	5	4	5	5	5	5	5
Organic Matter (%) (1)	0.1	.8	.7	1.0	0.9	1.2	0.7	1.3	0.5	2.8	2.3	2.0
pH (units) 1:2 Soil/Water; 1:1 Soil/Water; 1:2 Soil/CaCl2; Sat. Extr.	7.2 7.2	7.8 7.7 7.55 7.7	8.0(1)	8.1(1)(2)	7.4 7.40 7.46 7.9	7.5(1)(2)	8.1(1)	7.9(1)(2)	8.4 8.28 7.48 8.1	7.1(1)(2)	8.7(1)	8.1(1)(2)
Conductivity mmhos/cm Saturated Extract. (1)(2)(3)	.26 .40	3.3 3.68 3.42	.9	.58 1.63	8.6 3.43 2.79	4.0 5.15	3.8	3.5 2.53	3.00 4.68 2.81	3.15 3.96	1.30	3.00 3.43
Available Nutrients (1)												
NO_3 - N (lb/2x10^6 lb)	15	2	3	20	5	67	7	55	1	33	35	160
P	95	32	44	56	10	86	47	55	22	86	80	26
K	1000+	801	724	678	982	886	776	966	542	613	753	697
Ca	4755	9370	8927	8562	9059	8717	10000+	10000+	3593	4383	5153	4855
Mg	1000+	1000+	1000+	1000+	1000+	1000+	1000+	1000+	1000+	1000+	1000+	1000+
Na ppm	94		150	141		2050	2050	2200		685	980	845
S Sulphate ppm	30+	30+	30+	30+	30+	30+	30+	30+	30+	30+	30+	30+
B H_2O curcumin-oxalic ppm	.49		>.2	1.0		.66	.76	.24		.36	1.15	0.11
Cation Exchange (2)(3)(5)												
C.E.C. meq/100g	38.77	33.57		35.5	45.40	47.34		47.20	21.1	30.00		33.89
% Base Sat.	75.3	100+		100+	100+	77.7		83.9	100+	79.7		84.4
Σ Bases. meq/100g	29.20	48.40		40.72	56.35	36.77		39.61	21.74	23.91		28.61
Ca meq/100g	19.06	30.82		31.34	28.10	21.00		29.41	9.41	13.80		15.70
Mg meq/100g	7.326	13.92		7.61	13.92	11.32		8.98	8.82	9.07		12.11
Na meq/100g	0.602	1.87		0.53	12.67	3.28		-2.80	2.40	-0.73		-0.91
K meq/100g	2.21	1.79		1.24	1.66	1.17		1.22	1.11	1.04		1.26
Exchangeable Sodium %	1.6	5.6		1.5	27.9	6.9		?	11.4	?		?
Dissolved Anions & Cations (2)(3)(5)												
HCO_3^- meq/100g	nc	18.1×10^{-3}		nc	nd				nd	nc		nc
meq/litre	1.1	nc		1.6		nd		1.1		2.3		2.4
$CO_3^=$ meq/100g		nd			nd				nd	nc		nc
meq/litre	0			.3		nd		0		0.3		0.1
Cl^- meq/100g		.24			nd				.005	nc		nc
meq/litre	.63			2.24		nd		2.1		1.03		.90
meq/100g		.01			.11				.013			
SO_4 meq/100g		1.3			4.6	nc		nc	1.6	nc		nc
sat. ext. meq/litre	4.0											21.2
1:5 s/w ext meq/litre (2)				4.5		0.9		15.6		5.1		
B meq/100g		$<4.4\times10^{-4}$			670×10^{-4}				$<7.2\times10^{-4}$			
ppm		.38			.25				.14			
Ca meq/100g	0.105	.798		.53	.797	1.54		0.87	.474	.575		0.456
meq/litre	1.95	25.25		10.18	5.79	8.73		4.79	9.18	8.68		5.69
ppm	39			204		175		96		174		114
Mg meq/100g	0.044	.463		.24	.538	.93		0.33	.366	0.507		0.382
meq/litre	.82	14.65		4.69	3.91	5.27		1.81	7.10	7.65		4.77
ppm	10			57		64		22		93		58
Na meq/100g	0.068	.31		0.20	.30	8.13		3.71	.90	1.64		1.88
meq/litre	1.26	9.78		3.87	21.52	46.09		20.43	17.39	24.78		23.48
ppm	29			89		1060		470		570		540
K meq/100g	.02	.018		.03	.11	.36		.13	.059	0.11		0.117
meq/litre	.33	nc		.49	nc	2.02		.74	nc	1.66		1.46
ppm	13			19		79		29		65		57
Sodium Adsorption Ratio (5)	1.07	2.19		1.42	9.77	17.42		11.25	6.10	8.67		10.27
Water Content at Saturation (2) Wt % g H2O / g soil(dry)	53.69			51.72		176.36		181.46		66.24		80.14

	SEAM WASTE								ANTHROPOGENIC		
	CARBONACEOUS SHALE				COAL WASTE				FLY ASH		
Location	Trench A	Aleece Lake	Aleece Lake	Aleece Lake	Trench A	Aleece Lake	Aleece Lake	Aleece Lake	Aleece Lake	Aleece Lake	Aleece Lake
Sample Date	Mar 79	Jul 77	Apr 78	Mar 79		Jul 77	Apr 78	Mar 79	Jul 77	Apr 78	Mar 79
Texture <2.00mm %	82.2(5)	81.4(1)		89.5(5)	67.5(5)			73.3(5)	100%		100%
CSSS Tex Class (3)					Clay	Clay			SiL		SiL
% Sand (2)					18.72	13.9			32.3		22.1
% Silt (2)					32.71	30.0			58.7		69.53
% Clay (2)					48.56	56.10			9.0		8.37
BCDA Tex-Feel (1)	3	6	3	3	4	6	6	6	3	2	3
Organic Matter (%) (1)	18	30+	18	20	18	30+	30+	30+	2.8	1.2	1.4
pH (units) 1:2 Soil/Water; 1:1 Soil/Water; 1:2 Soil/CaCl2; Sat. Extr.	4.5(1)(2)	4.5 4.25 4.16 5.0	4.5(1)	5.0(1)(2)	4.8(1)(2)	5.0 4.81 4.68 7.3	4.0	3.7 3.7	7.1 8.01 7.87	9.1(1)	8.1(1)(2)
Conductivity mmhos/cm Saturated Extract. (1)(2)(3)	5.0 5.06	3.0 3.2 3.12	3.7	3.3 3.37	4.0 4.22	3.2 4.68 4.21	5.0	4.0 4.22	2.95 3.96	0.32	2.5 2.53
Available Nutrients (1)											
NO_3 - N (lb/2x10^6 lb)	160	96	83	92	25	16	7	16	55	8	102
P	68	16	20	46	35	17	17	74	56	38	40
K	503	235	326	439	383	591	284	376	165	111	173
Ca	8196	5965	6140	9859	6897	4432	3982	4369	3292	3097	2936
Mg	1000+	1000+	1000+	1000+	1000+	1000+	1000+	1000+	226	213	234
Na ppm	320		70	88	182		90	70		20+	26
S Sulphate ppm	30+	30+	30+	30+	30+	30+	30+	30+		17.6	30+
B H_2O curcumin-oxalic ppm	1.29		1.44	1.24	1.49		3.50	2.54	8.0+	11.09	10.54
Cation Exchange (2)(3)(5)											
C.E.C. meq/100g	76.99	86.41		93.13	42.34	60.79		77.57	9.28		5.43
% Base Sat.	44.89	48.1		43.24	100+	67.63		27.39	100+		100+
Σ Bases. meq/100g	34.56	41.55		40.27	42.62	41.11		21.25	14.12		10.22
Ca meq/100g	25.15	26.77		32.33	27.34	23.70		12.61	11.61		9.07
Mg meq/100g	8.51	13.66		7.08	13.74	14.94		7.55	1.68		.70
Na meq/100g	-0.16	.60		.29	.70	.78		.34	.46		.10
K meq/100g	0.90	.52		.57	.84	1.69		.75	.37		.35
Exchangeable Sodium %	?	0.7		0.3	1.7	1.3		0.4	5.0		1.8
Dissolved Anions & Cations (2)(3)(5)											
HCO_3^- meq/100g		3.8×10^{-3}				12.8×10^{-3}					
meq/litre	.5			.8	1.1			0.2			1.1
$CO_3^=$ meq/100g		0				nd					
meq/litre	0			0	0			0			0
Cl^- meq/100g		.01				.019			.011		
meq/litre	2.78	.013		1.66	.85			.76			1.21
meq/100g						.033					
SO_4 meq/100g		1.5				2.6					
sat. ext. meq/litre											
1:5 s/w ext meq/litre (2)	155.6			30.6	151.2			65.4			30.4
B meq/100g		8.8×10^{-4}				$.2\times10^{-4}$					
ppm		2.57				4.01			10.69		
Ca meq/100g	2.74	1.19		2.60	0.61	1.046		1.91			1.37
meq/litre	35.48	3.24		35.43	28.44	25.54		28.94			22.95
ppm	711			710	570			580			460
Mg meq/100g	1.65	.631		1.03	0.53	1.18		1.74			0.40
meq/litre	21.40	16.05		13.99	24.69	28.81		26.34			6.75
ppm	260			170	300			320			82
Na meq/100g	1.21	.089		.19	.20	.22		.19			.10
meq/litre	15.65	2.26		2.57	9.13	5.30		2.83			1.65
ppm	360			59	210			65			38
K meq/100g	0.08	.008		0.34	.02	.061		.06			.08
meq/litre	4.00	nc		4.60	.95	nc		.87			1.36
ppm	39			180	37			34			53
Sodium Adsorption Ratio (5)	2.93	0.83		0.52	1.77	1.02		0.54			.43
Water Content at Saturation (2) Wt % g H2O / g soil(dry)	77.18			73.48	21.45			66.15			59.62

nd - no data
nc - no calculation

(1) B.C. Ministry of Agriculture
(2) B.C. Ministry of Environment.
(3) B.C. Research for CMJV.
(4) Bulk Sample Field Lab.
(5) Calculations

C = Clay
L = Loam
S = Sand
Si = Silt

Table 2-2

1979 FERTILIZER ADDITION RATES ON RECLAMATION TEST AREAS

Test Area	Fertilizer Addition * (kg/ha)			
	11-48-0-0	46-0-0-0	0-0-62-0	0-0-0-21
Aleece Lake				
Colluvium	47	62	0	0
Glacial Gravel	47	62	0	0
Baked Clay	93	51	0	0
Gritstone	163	34	0	16
Bentonitic Clay	93	51	0	16
Coal Waste	47	62	0	0
Carbonaceous Shale	93	51	0	0
Fly Ash	42	23	84	0
Houth Meadows				
Gravel Slopes	47	62	0	16
Parent Material	280	6	0	16
Medicine Creek				
Till	47	62	0	16
Trench A				
3160' Carbonaceous Shale	47	62	0	0
3140' Baked Clay	47	62	0	16
3120' Gritstone	47	62	0	16
Coaly Waste	117	45	0	0
Trench B				
Gravel	140	40	0	16
Subsoil	140	40	0	16
Topsoil	93	50	0	16
Trench C	16-20-0-0			
Bentonitic Clay	112	34	0	16

* Numbers indicate percent by weight of N, P_2O_5, K_2O and Boron respectively.

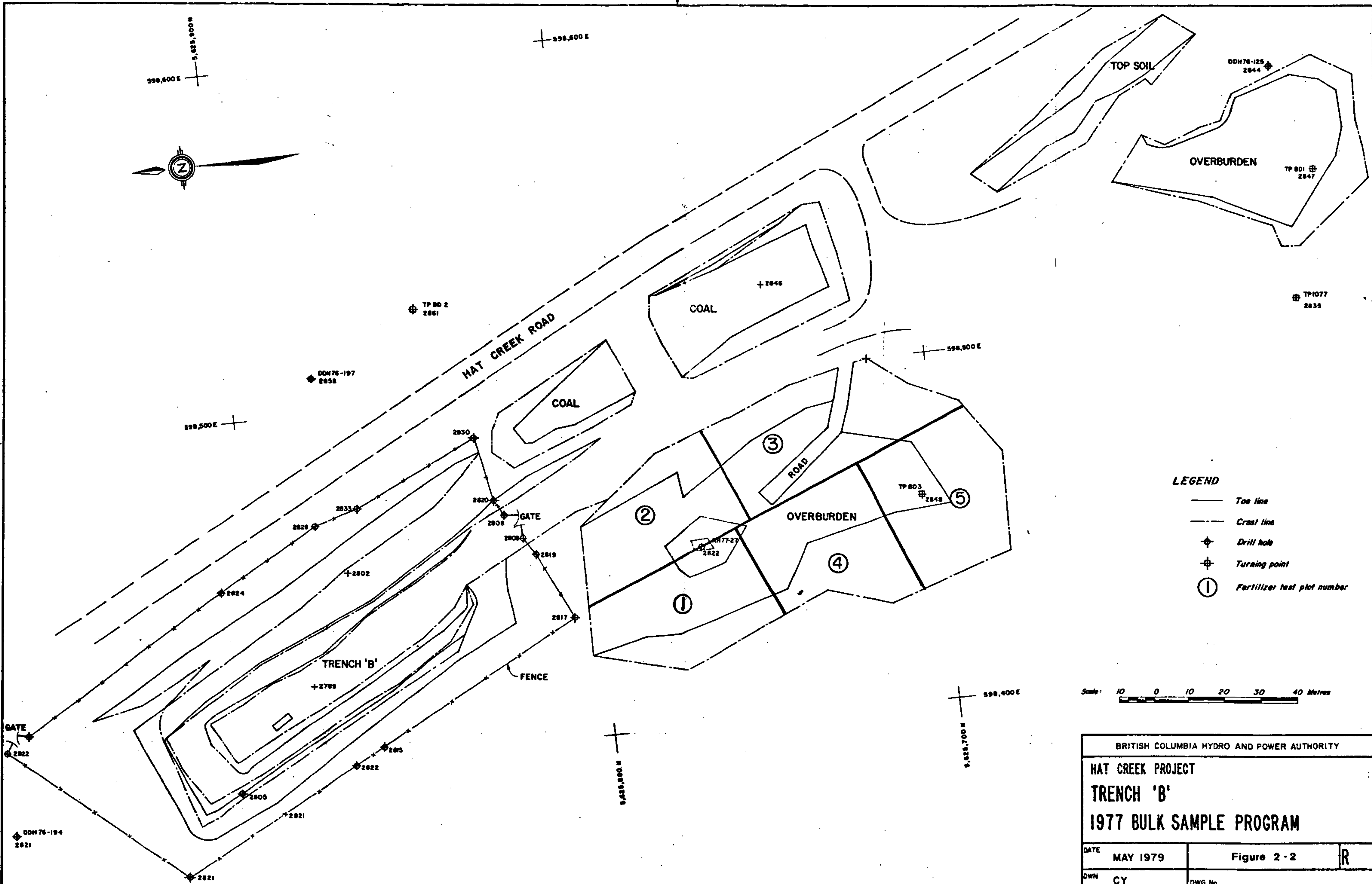
The remaining areas, the 3140 (baked clay) and 3120 (gritstone) dumps at Trench A, the large gravel dump at Trench B, the colluvium parent material at the Houth Meadows test area and the bentonitic clay dumps at Trench C, are being used to study the length of time that maintenance fertilizer must be applied for the establishment of abundant self-sustaining vegetation. These waste materials have been divided into five sections of approximately equal area, as shown in Figures 2-2, 2-3, 2-4, and 2-5. In 1979, segments numbered 1 at each location were not fertilized and the others received the recommended fertilizer additions. In 1980, segments numbered 1 and 2 will not be fertilized and in 1981 segments 1,2, and 3 will not received fertilizer additions. This system would be continued until 1984 when a detailed evaluation of revegetation success will be undertaken.

Fertilizer additions were made using both cyclone spreaders and a tractor mounted distributor. Applications were made during the week of 14 May 1979.

2.3 Vegetation Surveys

2.3.1. Introduction

In the spring of 1977 a reclamation test programme was initiated using waste materials from the Bulk Sample Program[1]. The success of this work was assessed quantitatively during 1978[2] and additional remedial measures were taken to improve the reclamation where necessary. In June and September 1979, additional environmental studies and field programmes were carried out to evaluate the contuing revegetation test programmes.



BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

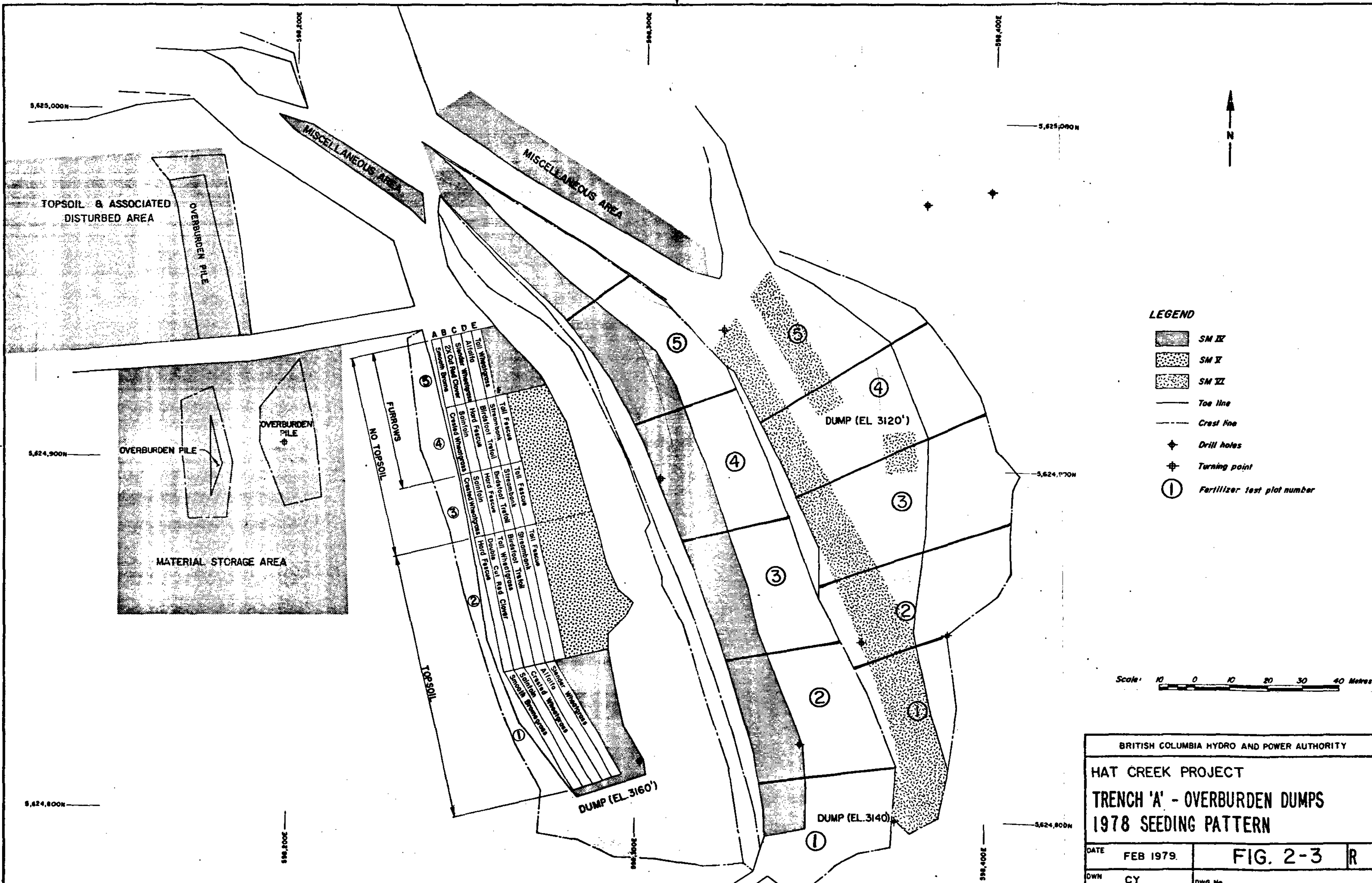
HAT CREEK PROJECT

TRENCH 'B'

1977 BULK SAMPLE PROGRAM

DATE MAY 1979	Figure 2-2	R
DWN CY	DWG No.	

REPORT No.



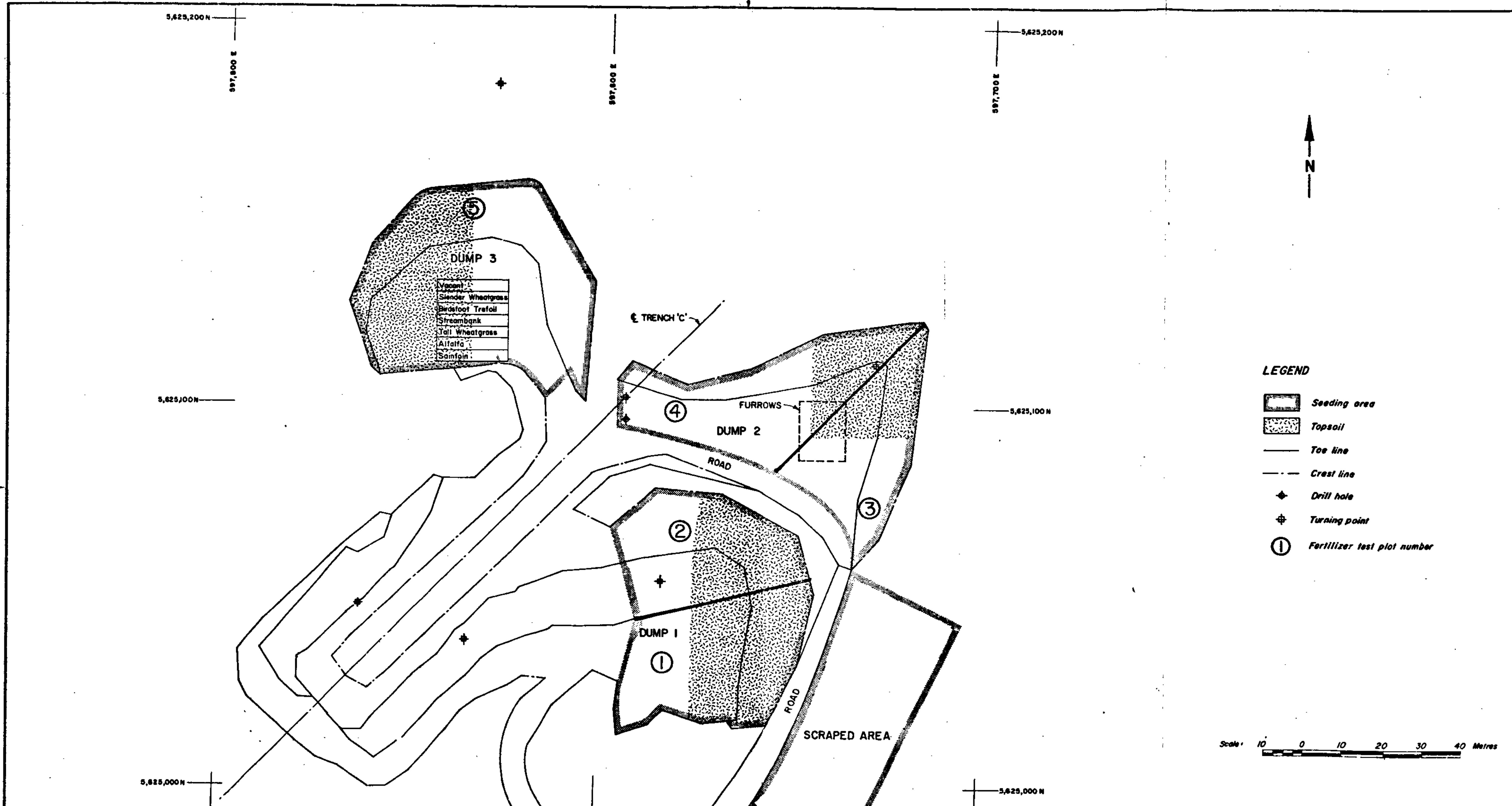
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

HAT CREEK PROJECT

TRENCH 'A' - OVERBURDEN DUMPS
1978 SEEDING PATTERN

DATE FEB 1979	FIG. 2-3	R
DWN CY	DWG No.	

REPORT No.



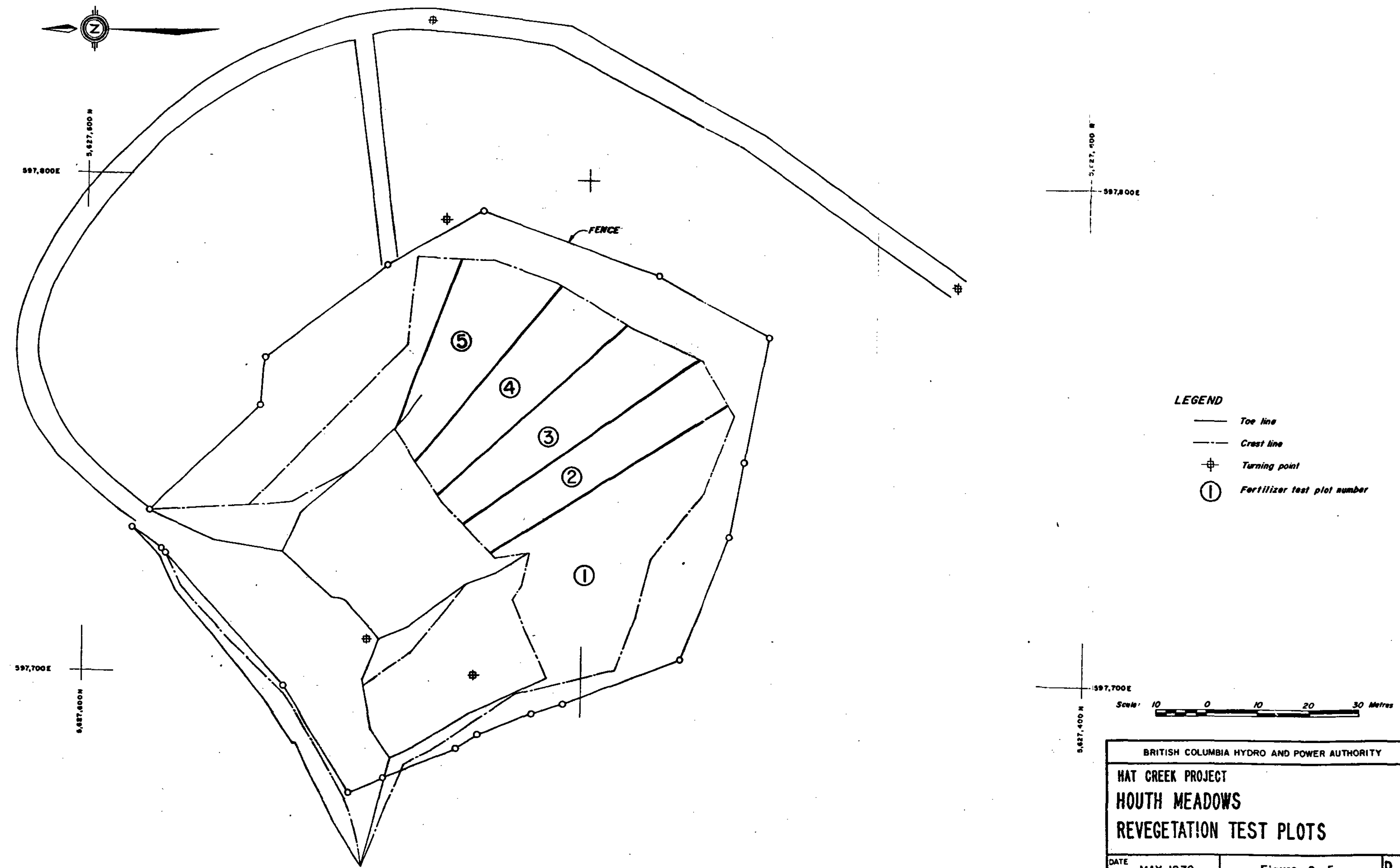
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

HAT CREEK PROJECT

SURFICIAL EXCAVATION-TRENCH 'C'
1978 SEEDING PATTERN

DATE FEB 1979	FIG. 2-4	R
DWN CY	DWG No.	

REPORT No.



BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

HAT CREEK PROJECT

HOUTH MEADOWS

REVEGETATION TEST PLOTS

DATE MAY 1979	Figure 2 - 5	R
DWN CY	DWG No.	

REPORT No.

This section summarises the results of the June and September field studies and presents an assessment of the success of the revegetation programme during 1979. These field studies were carried out by Acres Consulting Services Limited in conjunction with B.C. Hydro personnel.

2.3.2 Aleece Lake Test Plots

2.3.2.1 Vegetation Survey Methods - June 1979

The Aleece Lake test plots contain 46 populations: three seed mixes on seven soil materials with two surface treatments on each soil material, plus two seed mixes on one soil material with two surface treatments. These plots are described in the 1978 Environmental Field Program report[2]. Each population was evaluated quantitatively by estimating the total percent ground cover and the percent cover for each of the seeded species by visual inspection. Weed species were also identified and their percent cover was estimated. A description of each plant species including flower development, appearance and colour, was recorded. The overall success of the revegetation of each population was rated on an arbitrary scale of excellent, good, satisfactory and poor. In some cases intermediate classes designated by a + or - sign were assigned. This overall qualitative rating considers the appearance and visual condition of the vegetation (e.g. health, colour, maturity) and the yield or productivity as estimated by percent ground cover.

2.3.2.2 Results of Visual Growth Assessment - June 1979

The following results were found to be generally consistent on all eight soil materials tested at Aleece Lake:

Seed Mix I

Natural reseeding of fall ryegrass was not successful and only an occasional plant was observed. Clearly fall rye seeds are more successful or vigorous when tilled under the soil. However, foraging of the seeds by rodents and birds is suspected of contributing to heavy losses of fall rye seeds. The occasional fall rye plant may be the result of the germination of seeds planted in the fall of 1977[1], rather than from natural reseeding.

Crested wheatgrass was the dominant vegetation species on all test plots. It generally exhibited better performance on the topsoil portions of the plots, especially on the poorer materials. The percentage of plants which indicated maturity varied from plot to plot, much the same as after the first year.

Canada bluegrass did not make a major appearance on any of the materials. Present results showed no appreciable increase in Canada bluegrass success and this would appear to confirm the previous year's conclusion[2] that this species should be rejected for further use at Hat Creek because of very poor emergence success and growth.

Drylander alfalfa exhibited improved success on some of the "better" soil materials and was typically absent on the poorer materials such as coal waste and carbonaceous shale where it is suspected that the high acid levels inhibited germination. This effect was present even on the topsoil treated portions probably because the plot was rototilled before seeding.

Seed Mix II

Slender wheatgrass appeared to be the dominant species in Seed Mix II on all soil materials except baked clay where sainfoin was more dominant. Slender wheatgrass was more mature making it easier to identify than Russian wild rye. This species exhibited improved growth on the topsoil portions of the poorer materials.

Russian wild rye appeared less abundant on several of the materials compared with its abundance in the initial year. It is suspected that the juvenile plants which were relatively abundant in the summer of 1978 were not able to maintain growth once the end of the seedling stage was reached. Winter kill may also have been a factor.

Sainfoin generally exhibited improved performance in the spring of 1979. Those plants which overwintered are now beginning to mature and becoming well established. Sainfoin produced excellent results on the baked clay, colluvium and glacial gravels both with and without topsoil. The plants were generally less eminent on the other soils but nevertheless indicate good overwintering potential and persistent growth.

In the first summer after germination sainfoin was found to be most productive on the fly ash plot with topsoil. Examination of this same plot in the spring of 1979 indicated no major improvement, and possibly even decreased productivity. It is though that the topsoil initially promoted successful germination but that once the roots penetrated through into the fly ash growth was inhibited.

Sweet clover exhibited similar results to those which occurred in the first summer. This legume is less successful than sainfoin but showed good results on the better materials such as glacial gravels, baked clay and colluvium.

Generally the legumes of all seed mixes showed better performance on the perimeters of the plots where they were better established in the first year and competition from other species was reduced.

Seed Mix III

Streambank wheatgrass is the dominant species of Seed Mix III on all eight materials at Aleece Lake. This grass shows excellent overwintering success even on the poorer materials such as carbonaceous shale and coal waste. Although these materials generally exhibit unacceptable reclamation success, this grass should improve the ground cover in the long term since it can spread to new sites by virtue of its vigorous, rhizominous rooting system. Excellent results were displayed on the better soil materials. Streambank wheatgrass is one of the better plant species tested at Aleece Lake.

Smooth bromegrass indicated basically the same general trends as streambank, although this grass was less productive overall. The best results were on the gravels, colluvium and baked clay materials while less vigorous production occurred on the other materials. These observations were essentially similar to those noted in the first year. Smooth bromegrass is a highly recommended reclamation species at Hat Creek.

Double cut red clover exhibited similar trends to those found in the initial year. It does not appear to be a highly successful legume on even the better materials. The best results were obtained on the edges of plots of the better materials. The reasons for this success of the legumes (sweet clover and double cut red clover in particular) around the perimeters of the plots are presumed to be the result of reduced competition from the grasses.

Canada bluegrass (Rubens) was unsuccessful at the Aleece Lake test plots. This species was similar in performance to the common variety tested in Seed Mix I. Either the seeds were not viable or suitable conditions for germination never existed. Although not expected, it could develop later if more favourable conditions for germination occur.

<u>Waste Materials as Growth Media</u>

Essentially the same conditions prevailed in the spring of 1979 as those after one year, although cover, for the most part, has increased. The best vegetation growth was exhibited on the glacial gravels, baked clay and colluvium. Moderate improvement in vegetation growth was observed on the sandstone and bentonitic clay. Growth on the non-topsoil portions of the carbonaceous shale, coal waste and fly ash showed some improvement but continued to be unsatisfactory.

Topsoil results in better, sustained vegetative growth on the poor materials while there was basically no difference in reclamation success between the topsil and bare portions on the better materials.

Invader Species

Surprisingly, weed species were substantially less productive and less dominant compared to the previous year. Most weed species tend to be both less abundant and exhibited markedly less vigorous growth than last year. The agronomics are beginning to demonstrate their effectiveness in sustained and persistent growth on the test plots at Aleece Lake. The weed species (mostly annuals) are now having to compete with the well established agronomic species (perennials).

A summary of the overall success of the reclamation effort on the eight materials at Aleece Lake as determined in the June 1979 survey is given in Table 2-3.

2.3.2.3 Vegetation Assessment Method - September 1979

Each test plot at Aleece Lake was inspected and the following data noted:

- the relative abundance of each seeded species and the abundance of weeds;
- the total percent ground cover according to the following scale:

  1 = 0 to 25%
  2 = 26 to 50%
  3 = 51 to 75%
  4 = 76 to 100%.

- general observations on the maturity and condition of the plants.

Table 2-3

Summary of Overall Success of Reclamation on Aleece Lake Test Plots

MATERIAL		SEED MIX I	SEED MIX II	SEED MIX III
SURIFCIAL				
Colluvium	without topsoil	excellent	excellent	excellent
	with topsoil	good^{+}	excellent	excellent
Baked Clay	without topsoil	good^{+}	excellent	excellent
	with topsoil	good^{+}	excellent	excellent
Glacial Gravels	without topsoil	good	good	excellent
	with topsoil	good^{+}	excellent	excellent
NON-SEAM WASTE				
Gritstone	without topsoil	good	good	satisfactory
	with topsoil	good	excellent	excellent
Bentonitic Clay	without topsoil	satisfactory	satisfactory	satisfactory
	with topsoil	satisfactory	satisfactory	satisfactory
SEAM WASTE				
Coal Waste	without topsoil	poor	poor	satisfactory
	with topsoil	satisfactory	poor	good^{+}
Carbonaceous Shale	without topsoil	poor	poor	poor
	with topsoil	good	satisfactory	satisfactory
ANTHROPOGENIC				
Fly Ash	without topsoil	satisfactory	poor	-
	with topsoil	good	good^{+}	

Note: Rating includes consideration of degree of cover, maturity of plants and plant condition.

In addition, the populations of each test plot were ranked from 1 to 6 (fly ash 1 to 4) according to their overall revegetation performance. The population ranked 1 was best and that ranked 6 (4 on fly ash) the worst.

2.3.2.4 Results of Visual Growth Assessment - September 1979

Seed Mix I

Crested wheatgrass is the dominant species of Seed Mix I on all eight test plots. This species has become quite well established and generally provides good ground cover. It has a high proportion of mature plants.

Alfalfa is the only other seeded species of Seed Mix I that has become established at Aleece Lake. It is generally most successful in those areas where competition from other plants is reduced. In such areas the size of the alfalfa is significantly increased.

The vegetation cover is usually less for Seed Mix I because it contains only one grass species that has become established while both Seed Mix II and Seed Mix III have two grass species that have become well established.

Seed Mix II

The grasses Russian wild rye and slender wheatgrass appear to compete successfully with the legumes, particularly sainfoin, in providing a good balance of grass/legume ground cover.

Sweet clover is the least successful and more variable of the species tested in Seed Mix II. Overall this legume was not highly successful (abundant) but in some areas the plants had obtained excellent size. Since sweet clover is a biennial it is suspected that this legume will largely die out. Establishment through natural reseeding is not expected to be particularly successful.

Sainfoin is a highly successful legume which consistently exhibited good results except in areas of excessive grass ground cover.

Seed Mix III

Streambank wheatgrass and smooth bromegrass are both successful grass species and appear to compete well with one another. Streambank is generally the more abundant of the two due to its ability to spread rapidly by rhizomes and form dense ground cover. Smooth brome was less successful especially on the poorer materials.

Double cut red clover has not been a successful legume, exhibiting poorer performance than sweet clover. It is present in limited quantities around the periphery of the plots where competition from other species is absent.

2.3.2.5 Waste Materials as Growth Media

Colluvium

After two growing seasons there was essentially no perceptible difference in performance of the seed mixes between the topsoil and non-topsoil portions of the plot. The only major difference between the topsoil areas and the non-topsoil areas was a greater abundance of native species on the topsoil side.

The colluvium plot had the greatest ground cover of all the Aleece Lake plots. The vegetation consists almost entirely of grasses which are forming a very dense mat over the surface. The legumes sainfoin, alfalfa and sweet clover are much reduced in abundance compared to other plots. In the case of sainfoin there was a marked decrease in abundance from the June 1979 evaluations.

The vegetation appears relatively healthy considering the low moisture condition at Hat Creek. A high proportion of the established vegetation is in the flowering or seeding state. Native species are present but not abundant.

Cover estimates for Seed Mix I are less than the other two seed mixes. This is presumed to be due to a carry-over from the excessive competition from the fall rye in the first year.

Colluvium

Population		Rating	Cover Index
Seed Mix III w/o TS	similar	1	4
Seed Mix III w TS		2	4
Seed Mix II w/o TS	no difference	3	4
Seed Mix II w TS		4	4
Seed Mix I w/o TS	similar	5	3
Seed Mix I w TS		6	3

Glacial Gravels

The vegetation is healthy, mature and exhibits good ground cover. Grass, mainly crested wheatgrass, is the dominant vegetation on Seed Mix I. Seed Mix II exhibits a good balance of grass and legume. As with the colluvium there is no major difference in seed mix performance between the topsoil and non-topsoil. Grasses are also the dominant vegetation in Seed Mix III. Double cut red clover exhibited its best performance (good abundance) of all the test plots on the glacial gravels.

Native species are not particularly abundant on the topsoil, however there were a number of large thistle plants (around the edges in particular) on the glacial gravel plot which are disseminating a very large amount of seed. Thistle plants are very tolerant of harsh conditions and establish very quickly. Should these seeds germinate it could cause a significant reduction in the performance of the agronomic species.

Glacial Gravel

Population		Rating	Cover Index
Seed Mix II w/o TS	very similar	1	4
Seed Mix II w TS		2	4
Seed Mix III w TS	very similar	3	4
Seed Mix III w/o TS		4	4
Seed Mix I w/o TS	very similar	5	3
Seed Mix I w TS		6	3

Baked Clay

The results on the baked clay plot are basically identical to those obtained on the glacial gravels with some minor exceptions: Alfalfa showed greater abundance on both topsoil and non-topsoil, and double cut red clover exhibited poorer success on the baked clay. Vegetation is healthy, mature and forms a good ground cover on both topsoil and non-topsoil.

Baked Clay Population		Rating	Cover Index
Seed Mix II w/o TS	similar	1	4
Seed Mix II w TS		2	4
Seed Mix III w/o TS	similar	3	4
Seed Mix III w TS		4	4
Seed Mix I w/o TS	similar	5	3
Seed Mix I w TS		6	3

Gritstone

Vegetation growth is substantially better on the top-soiled areas, where the ground cover is more uniform and the condition of the vegetation is better. Generally the vegetation on the gritstone plot is healthy and the plant maturity is good.

Sainfoin exhibits particularly good performance on the non-topsoil areas of the plot where it is the dominant species. Smooth brome is the dominant species of Seed Mix II on the non-topsoil material. Weed species are moderately abundant on the topsoil, especially on the Seed Mix III topsoil.

Gritstone Population	Rating	Cover Index
Seed Mix II w TS	1	3
Seed Mix III w TS	2	3
Seed Mix I w TS	3	2
Seed Mix II w/o TS	4	2
Seed Mix III w/o TS	5	2
Seed Mix I w/o TS	6	2

Bentonitic Clay

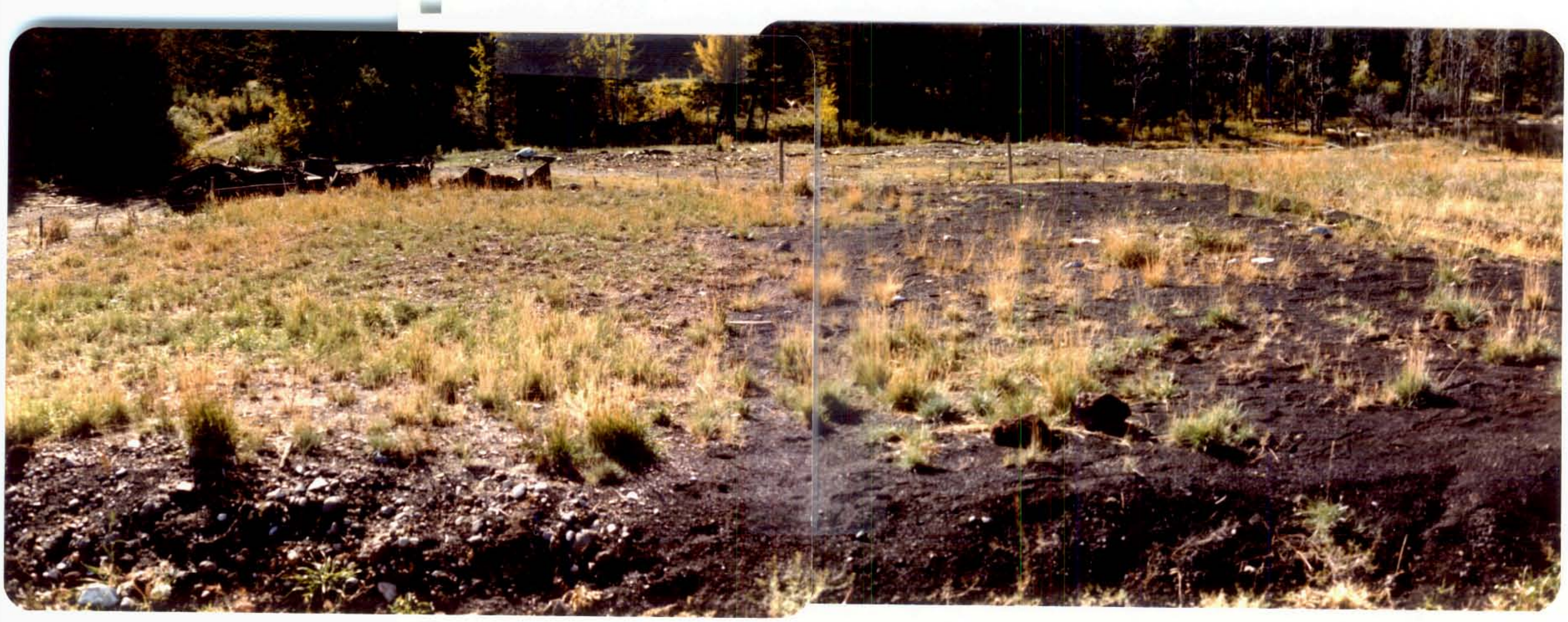
Vegetation is consistently better on the topsoil sides of the plot with all three seed mixes. The plants are greater in size and more abundant than on the raw material. Overall, there is not a high proportion of mature plants on the bentonitic clay, and there is a significant amount of chlorosis, especially on the raw material. Native species invasion is low.

Bentonitic Clay Population		Rating	Cover Index
Seed Mix II w TS	very similar	1	3
Seed Mix I w TS		2	3
Seed Mix III w TS		3	3
Seed Mix III w/o TS	very similar	4	2
Seed Mix II w/o TS		5	2
Seed Mix I w/o TS		6	2

Coal Waste

Vegetation is better established on the topsoil side of the plot for all seed mixes. Generally the plants are larger and ground cover is much improved on the topsoil. Vegetation does not appear to have been severely affected by the dry summer and most plants appear relatively healthy, even on the raw material.

Streambank wheatgrass exhibited striking success on the non-topsoil material where the grass attained considerable size and good abundance.



Coal Waste Population	Rating	Cover Index
Seed Mix III w TS	1	3 (small plants)
Seed Mix I w TS	2	2
Seed Mix II w TS	3	2
Seed Mix III w/o TS	4	1
Seed Mix II w/o TS	5	1
Seed Mix I w/o TS	6	1 (large plants)

Carbonaceous Shale

This material had the poorest vegetation performance of all waste materials tested. The non-topsoil side of the plot was essentially devoid of any growth except for the odd patch of grass growing in a decpression, or where the vegetation from the topsoil is encroaching onto the bare material. Seed Mix II was completely bare of any growth. Vegetation performance on the topsoil was much improved over the non-topsoil but was still unsatisfactory. The cover was not uniform, and the plants exhibited poor maturity and health. Crested wheatgrass exhibited the best success of any of the applied species. Weed species were present but not abundant on the topsoil.

Carbonaceous Shale Population		Rating	Cover Index
Seed Mix I w TS		1	2
Seed Mix III w TS		2	2
Seed Mix II w TS		3	2
Seed Mix III w/o TS	very similar	4	1
Seed Mix I w/o TS	very similar	5	1
Seed Mix II w/o TS	very similar	6	1

Fly Ash

Vegetation growth on the fly ash plot was poor. The best results were seen on the topsoil sides of both seed mixes.

Seed Mix II generally provided better ground cover than Seed Mix I, except on the raw fly ash. Vegetation on the fly ash was chlorotic and dried-out. Only the largest of the legumes exhibit flowering. Vegetative cover on the non-topsoil portions of the fly ash was patchy, especially with Seed Mix II, where the ground cover was unsatisfactory. Native species were not particularly abundant and were present only on the topsoiled half of the plot.

Fly Ash Population		Rating	Cover Index
Seed Mix II	w TS	1	3
Seed Mix I	w TS	2	3
Seed Mix I	w/o TS	3	2
Seed Mix II	w/o TS	4	1

2.3.3 Sloped Test Plots

The sloped test plots at Houth Meadows and Medicine Creek were seeded in the fall of 1977 using a single seed mix, SMI. A small area of parent material at the Houth Meadows test area was seeded by harrow and the remaining areas were hydro-seeded.

2.3.3.1 Vegetation Survey Methods - June 1979

Two 0.1m^2 quadrats were located randomly along the upper and lower portions of each of the six sloped populations. The total number of plants of each seeded species were recorded for each of the quadrats. Weed species were counted and identified. The total percent ground cover was determined. The average plant heights and condition of the vegetation were also recorded. The success of the revegetation of each sloped population was then rated on a scale of excellent, good, satisfactory, and poor, the same rating as that used to evaluate the Aleece Lake test plots.

2.3.3.2 Results of Visual Growth Assessment - June 1979

Houth Meadows

Basically there was no significant difference in the success of the reclamation on the three different slopes. There was, however, a recognisable difference in the degree of reclamation success between the non-topsoil and topsoil treated portions of the slopes. On all three test slopes the vegetation exhibited better productivity and ground cover on the non-topsoil treated portions. These results can be attributed in part to the absence of weed competition on the bare material during the first year. The addition of topsoil resulted in a substantial decrease in the number of plants produced and their productivity. Although invader species were not nearly as abundant as in the first year, the effects of this competition have clearly affected the seeded agronomic species.

Fall rye grass did not reseed at Houth Meadows, where it was almost completely absent. The occasional fall rye grass plant was observed, but it is suspected that their presence was a result of germination of seeds of the initial seed mix rather than from seeds dispersed from the plants themselves.

The major vegetation components on the sloped plots were crested wheatgrass and alfalfa. Crested wheatgrass was more abundant while the alfalfa was more productive in terms of total biomass present.

Vegetation cover on the sloped plots was patchy, as observed after the first year, due to an uneven dispersal of the seed mixture. The loss of fall rye grass, and possibly some winter kill of alfalfa, have resulted in slightly poorer ground cover conditions compared to last year, especially on the topsoil. Eventually the continual growth of agronomic species should produce a more evenly distributed ground cover.

It was not possible to detect any significant difference in growth between the upper and lower portions of the slopes. Theoretically the lower portions should reflect better growth due to the increased water runoff, however, this effect was not found to be consistent between the slopes.

Examination of the slopes indicated that erosion does not appear to be significant after two years.

Overall Success of Reclamation at Houth Meadows Test Plots - June 1979

30° slope	Topsoil	-	poor
30° slope	Non-topsoil	-	satisfactory
26° slope	Topsoil	-	poor
26° slope	Non-topsoil	-	satisfactory+
22° slope	Topsoil	-	poor
22° slope	Non-topsoil	-	satisfactory+

The level areas at the base of the sloped plots at Houth Meadows were also examined. The harrow-seeded section exhibited poorer productivity than the hydro-seeded portion. This effect, which is the exact opposite of the first year results, can be attributed to the loss of the fall rye, which was the dominant species on the harrowed area last year. The harrowed area did, however, show a good balance between grass and legume. On the hydro-seeded area drylander alfalfa was present almost exclusively. It exhibited excellent productivity likely due to the absence of competition from fall rye (during the initial year) and perennial crested wheatgrass.

Medicine Creek

The greatest productivity was observed on the 30^{o} slope where the plants are more abundant and larger. The individual test plots exhibited fairly uniform vegetative cover over the entire length of the slopes, however, the drylander alfalfa appeared to be more productive on the lower levels.

Crested wheatgrass, the dominant species on the test plots, exhibited excellent results, while the alfalfa appeared less vigorous. The fall rye grass, the dominant species in the first year, was not present in the second year. The reasons for the relatively poor productivity of the alfalfa, in comparison to Houth Meadows, are not clear. One possible explanation would be the competition from the crested wheatgrass.

Erosion does not appear to be a major concern at Medicine Creek after two years.

There was evidence of substantial rodent populations at Medicine Creek. Disturbance of the soil by the rodents, through nesting cavities, may eventually lead to some localised erosion problems. It is suspected that the rodents are also responsible for some losses in plant productivity. Although the test area is fenced, it appeared that some disturbance by deer and horses may have occurred.

The revegetation at Medicine Creek were slightly better than at the Houth Meadows test plots. The productivity of drylander alfalfa at Medicine Creek was not as great while the vegetation cover was less patchy than at Houth Meadows.

Overall Success of Revegetation at Medicine Creek Test Plots - June 1979

22° slope	-	good
26° slope	-	good
30° slope	-	good

Overall, the June 1979 results at Medicine Creek indicate that successful revegetation of dump faces comprised of in situ till, with slopes up to 30°, has been achieved in the second year after initial seeding.

2.3.3.3 Vegetation Sampling Methods - September 1979

Plots were inspected visually and a qualitative assessment of revegetation success was made. Examination of quadrats and identification of agronomic and weed species was not carried out.

2.3.3.4 Results of Visual Growth Assessment - September 1979

Houth Meadows

The only major difference between the September and the June assessments is that the vegetation is much drier, and consequently browner, in the late summer. This can be attributed to the extremely dry summer. This lack of moisture which was evident in the condition of the vegetation on the test plots, was also very evident in the native vegetation in the surrounding areas.

Based on the September 1979 visual assessments the following statements can be made of the three test slopes at Houth Meadows:

- The abundance of individual species, total cover, and condition of vegetation at the three sloped test plots showed consistently better results on the non-topsoil sides of the slopes. Drylander alfalfa is the dominant species on the non-topsoil slopes. Crested wheatgrass is the major seeded species on the topsoil sides of the slopes

- Crested wheatgrass exhibited substantially more browning than alfalfa. This may be, however, the nature of the grass at this particular time of year.

- The poor growth of agronomics on the topsoil is thought to be related to the competitive effects of native species which were extremely abundant.

- Invader species were essentially insignificant in terms of abundance and size on the non-topsoil portions of the plots.

- Vegetative cover was relatively uniform throughout the slope of the plot.

- Two areas of localised erosion were noted: at the top of the 30° topsoil slope, and on the lower 1/3 portion of the 26° non-topsoil slope. This erosion may be attributable to the heavy rainfall - 1 inch in 4 hours was recorded about two weeks before the inspection. At the top of the 30° topsoil slope the land is contoured to collect moisture and direct it down the waste dump face. This caused the erosion channel on the 30° slope. Rodent disturbance (nesting cavities are abundant throughout the area) may also have contributed to the erosion.

Medicine Creek

This test area exhibited slightly different results from those observed at Houth Meadows:

- At Houth Meadows there was a better balance between crested wheatgrass and alfalfa abundance whereas at Medicine Creek crested wheatgrass was clearly the more abundant. The alfalfa plants present at Medicine Creek were generally very small.

- The ground cover was much more uniform, and the vegetation appears to be less dry at Medicine Creek.

- Weed species were not numerous at Medicine Creek.

- Erosion, other than that caused by rodent nesting, was not apparent on any of thre three slopes.

2.3.4 Bulk Sample Program Waste Dumps

Waste materials extracted from Trench A were dumped to form three benches at elevations of 3120' (gritstone), 3140' (baked clay) and 3160' (carbonaceous shale). At Trench B the topsoil, subsoil and gravel were stockpiled separately. At Trench C the waste material, bentonitic clay, was dumped in three waste dumps adjacent to the trench. These areas are described in the Bulk Sample Program Report[1] and the 1978 Environmental Field Programs Report[2].

Revegetation of these areas was commenced in 1977 at Trench A and Trench B and in 1978 at Trench C. In 1978, portions of the waste dumps at Trench A were reseeded in areas where the 1977 work was not successful.

2.3.4.1 Vegetation Sampling Method - June 1979

Revegetation success was assessed qualitatively. Plant species were identified and their average plant height and condition of health were noted.

2.3.4.2 Results of Visual Growth Assessment - June 1979

Trench A

3160' Dump Surface

The best germination success from the 1978 seeding occurred in the furrowed area to the north end of the dump where the moisture was clearly better retained. Germination was disappointing on the topsoiled portion of the dump. Although germination success among seed mixes was very similar the potential for good ground cover did not appear good. Vegetation was absent on the non-topsoil, non-furrowed portion of the dump.

3160' Dump Face

Vegetation success on the dump face had considerably improved in comparison to the first year results. Crested wheatgrass exhibited excellent growth and maturity. Alfalfa was very abundant but the plants were small and immature. Canada bluegrass was present but not abundant. Invader species were essentially absent. Vegetation cover was generally uniform over the dump face except in areas that had been disturbed by cattle.

No noticeable difference in vegetation success was evident between the 26° and 34° slopes. The waste material of this dump face is the same as that on the surface, carbonaceous shale. The fact that revegetation was successful on the untreated face but not on the surface is difficult to explain. It is possible that there were more moisture collecting microsites on the slope which improved germination.

No major erosion was noted on the slopes but several areas showed signs of rill erosion.

3140' Dump Surface

The dump surface, which was reseeded in the fall of 1978, had satisfactory growth. Most germination occurred in the furrows left by the harrow. All five species in Seed Mix IV exhibited some success, but the sainfoin, wheatgrasses and smooth brome indicated best results.

3140' Dump Face

In the fall of 1978 there was a high concentration of juvenile plants which were expected to develop in the spring of 1979. Examination of the 3140' dump faces indicates that these have developed. Crested wheatgrass was the dominant species although the grass/legume ratio was satisfactory. Vegetative cover was relatively uniform over the dump faces. There was no apparent difference in productivity between the two dump faces of slopes 26° and 34°.

Despite much evidence of cattle grazing and surface disturbance, growth on the dump face was quite satisfactory.

3120' Dump Surface

Vegetative growth of Seed Mix VI on the newly seeded area at 3120' indicated similar success as on the 3140' bench surface. There was an abundance of juvenile vegetation, especially grasses. Birdsfoot trefoil did not appear to be a successful legume.

Similar to the 3140' bench surface, the initial germination success on the 3120' surface appeared in the furrowing of the soil surface left by the drag harrow.

Growth on the dump surface area which was not reseeded in 1978 was less than satisfactory. Crested wheatgrass exhibited the best success of the species in Seed Mix I, however, the vegetation growth on the clayey material was patchy and exhibited moisture stress. Vegetation has persisted in small depressions where moisture could collect.

3120' Dump Face

Vegetation success on the claystone dump faces was more satisfactory than on the dump surface. Crested wheatgrass showed surprisingly good growth. Alfalfa, the only other species growing, was less abundant and not as productive. Vegetative growth on the slopes occurred in furrows and ruts where moisture collection was more effective. No major difference was evident between the 20° and 30° slopes. On the 38° slope vegetation cover was very patchy with some good stands. However, there were large areas which were completely devoid of vegetation. Erosion was not a major problem.

Trench B

Topsoil Pile

The agronomics were doing poorly on the topsoil pile. The growth of the agronomics was obviously inhibited by the invader weed species which were exceedingly abundant. Crested wheatgrass, alfalfa and Canada bluegrass were all present but the plants were small.

Subsoil Pile

The revegetation success on the subsoil pile was very satisfactory. Invader species, which were relatively abundant in the first year, were less prominent than the agronomics.

Vegetation cover was excellent. Crested wheatgrass and alfalfa were the major vegetation on the plot. Canada bluegrass exhibited improved success over the last year for reasons which are unknown. The bluegrass plants were juvenile which suggests that the conditions for germination may have been better this year, while the seeds remained dormant in the first year.

Gravel Pile

Growth on the harrow-seeded area of the gravel pile was excellent. Crested wheatgrass and alfalfa are the only vegetation species on the plot. Vegetative cover was essentially uniform over the entire area.

The hydro-seeded area of the gravel pile showed particularly good success for the drylander alfalfa. This was expected after initial examination of the area last year. Alfalfa has exhibited excellent success wherever fall ryegrass was not the dominant species in the initial year. In this hydro-seeded area the alfalfa and crested wheatgrass were present in approximately equal quantities, with the alfalfa plants exhibiting excellent productivity.

Trench C

Three waste dumps at Trench C were seeded and fertilised in September 1978. The seed mixes applied were selected on the basis of the Aleece Lake results. This section of the report presents a summary and discussion of the early spring growth results at Trench C.

Dump 1

Vegetation on the level area was very patchy with growth clearly better in the small depressions. Vegetation cover appeared to be better on the topsoiled areas. Growth results on the bentonitic clay at Aleece Lake indicated similar improved success on the topsoil side.

On the slopes, growth on the topsoiled portion, although patchy, was consistently better than on the bare material. With topsoil cover the slopes were more prone to erosion.

Dump 2

Germination success of Seed Mix VI was noticeably better in the furrowed areas at Dump 2. There was no apparent difference in reclaim success between the non-topsoil and topsoil portions of the level area. Weed species were more abundant on the topsoil portion but were not excessively productive. The three wheatgrasses and alfalfa exhibited good abundance of juvenile plants.

Growth on the bentonic clay slopes indicated similar species diversity as the level areas but better individual plant productivity. This was the same general trend found at all test areas at Hat Creek. The sloped areas have ruts and channels which trap water and promote germination.

Dump 3

Early spring growth was not outstanding on the Dump 3 area at Trench C. Overall, the grasses indicated much better success on the topsoil portions. The legumes appeared to be doing well on the bare material.

Of the new seed species selected for testing at Trench C the hard fescue and tall wheatgrass appear to be taking well. Birdsfoot trefoil was selected as a legume with acid tolerance, however, it was proved unsuccessful in all areas tested. It is suspected that this species may not be sufficiently drought-tolerant for use at Hat Creek.

2.3.4.3 Vegetation Sampling Method - September 1979

Vegetation was assessed in the same way as in June 1979.

2.3.4.4 Results of Visual Growth Assessment - September 1979

Trench A

3160' Dump Surface

Of the five areas seeded in 1978 on the carbonaceous shale waste dump, only two areas showed satisfactory growth. These areas, seeding pattern areas 4 and 5 shown in Figure 2-3 in the 1978 Environment Field Programs Report[2] had been furrowed while the other three had not. Growth was restricted almost entirely to these furrows. The 11 species tested showed some success (tall wheatgrass, slender wheatgrass, crested wheatgrass, tall fescue, hard fescue, streambank wheatgrass, birdsfoot trefoil, sainfoin, alfalfa, double cut red clover and smooth brome) although the grasses exhibited the best results. Double cut red clover exhibited poor success and only one birdsfoot trefoil plant appeared.

The relative success of the vegetation growing in the furrows is thought to be attributed to the ability of the furrows to trap water. The carbonaceous shale tends to be hydrophobic; normally when water collects in puddles on the surface it does not easily wet the soil below approximately 5 mm.

Seeding pattern area 3 where the carbonaceous shale was seeded "as is" without either topsoil addition or furrows, was completely devoid of any vegetation.

Seeding pattern areas 1 and 2 have a surficial capping of topsoil (approximately 15 cm) but do not have furrows. Agronomic species sown showed poor success compared to other areas sown in 1978 and compared to the furrowed areas on bare carbonaceous shale. In addition to poor cover the plants were generally small and immature. Weed species were relatively abundant compared to the seeded species though their quantities were not nearly sufficient to provide the same level of competition as on the Trench B topsoil pile or the topsoiled portion of the Houth Meadows dump. The weed species were generally large and mature. All agronomic species tested exhibited some success, with the exception of birdsfoot trefoil.

3160' Dump Face

Vegetation success was good on the dump face. Crested wheatgrass and alfalfa were about equal in abundance but overall the slopes were somewhat patchy and waterborne erosion channels were fairly significant. Overall the vegetation appeared in a healthy condition. Weed species were not particularly abundant on the slopes.

3140' Dump Surface

The vegetation on the baked clay dump surface exhibited excellent success. Ground cover was very high and uniform throughout. Of the three grasses (smooth brome, crested wheatgrass and slender wheatgrass) and two legumes (sainfoin and alfalfa) applied, sainfoin appears to be the more successful species, while alfalfa exhibited poorest success. Canada bluegrass was also present at the northern end of the dump presumably from the initial seeding in 1977.

3140' Dump Face

The dump face has shown consistent improvement in vegetation success. The ground cover was relatively uniform, and the vegetation (crested wheatgrass and alfalfa) was green and had a high proportion of mature plants. Weed species were present but not abundant. Wind and/or waterborne erosion was not observed to be significant on the slopes. This dump face had been disturbed by cattle and consequently had some patchy areas of ground disturbance and grazing.

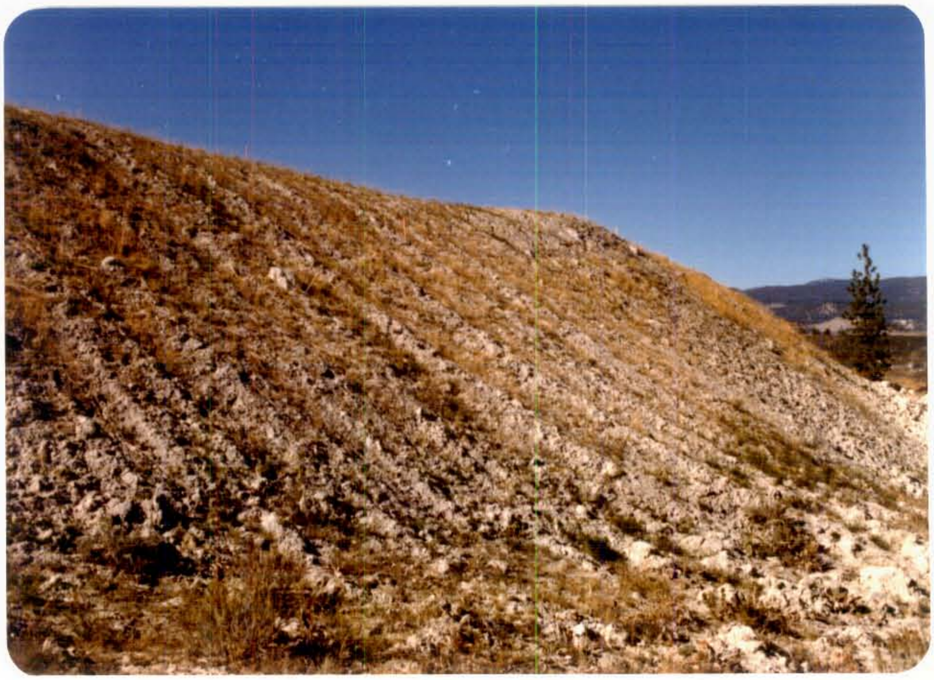
3120' Dump Surface

Vegetation success on the gritstone (claystone) material was mixed, with some large areas of poor success. The vegetation that did become established, crested wheatgrass and alfalfa, is somewhat stunted, chlorotic and very dry. Overall the condition of the vegetation on this portion is unsatisfactory. The surface material is clayey and dries to a very hard crust which seems to inhibit plant development. The results at Aleece Lake indicated that this material should be easier to revegetate than it appears to be at the Trench A waste dump.

On the baked clay area, at the western portion of 3120' bench surface, vegetation success was much better. Although Seed Mix VI was applied on the 3120' bench surface, the results are basically similar to that obtained on the baked clay at 3140' where Seed Mix IV was planted. The three grasses (streambank, slender and tall wheatgrass) exhibited good germination success but were still somewhat juvenile, whereas the legumes (alfalfa and birdsfoot trefoil) showed limited success. Typically, birdsfoot trefoil did not develop at all, and alfalfa showed scattered success.

<u>3120' Dump Face</u>

The gritstone dump faces exhibited vegetation success primarily in ruts left by bulldozers. Ground cover was variable with relatively good cover on the 20° and 30° slopes while cover on the steepest, the 37° slope, was scattered and generally unsatisfactory. The vegetation that had become established was somewhat stunted and very dry. Crested wheatgrass was more abundant than alfalfa.



Trench B

Topsoil Pile

Native species growth has been quite intense during the past two years and this has led to the situation where the establishment of the agronomics has been almost negligible. Both crested wheatgrass and drylander alfalfa were present on the topsoil pile but in very low proportions and they were stunted and immature.

Subsoil Pile

The condition of the vegetation on the subsoil pile was similar to that of the gravel pile. There was a good balance of grass and legume with an overall uniform ground cover. At the time of inspection the crested wheatgrass was browning, while the alfalfa was still green and healthy, with some minor chlorosis. There was a relatively high abundance of weed species present.

Gravel Pile

On the harrow seeded portion, the crested wheatgrass and alfalfa appeared healthy and were basically equally abundant. The ground cover was good. On the hydro-seeded area, the alfalfa was the better established species, some plants were over 70 cm high. Crested wheatgrass appeared to be more dried out than the alfalfa. The alfalfa exhibited chlorotic lower leaves.

Trench C

Dump 1

Despite the relative lack of moisture this past summer, there was substantial germination success on the topsoil surface of Dump 1. All species showed some success except birdsfoot trefoil. Generally, the plants were small, somewhat dried-out and juvenile. The topsoil dump face exhibited much the same plant diversity and ground cover as the dump surface, but overall the grasses were larger and healthier.

Vegetation success on the non-topsoil dump face and surface was poor. Ground cover was very patchy and the vegetation generally drier and smaller than on the topsoil.

Dump 2

The furrowed area in the centre of Dump 2 showed the best results, both on the topsoil and non-topsoil presumably due to improved moisture collection. Alfalfa and juvenile grass species were quite abundant; birdsfoot trefoil did not develop. There is a substantial abundance of weed species on the topsoil areas of Dump 2. Apart from the furrowed areas, vegetation did not develop well on the non-topsoiled dump surface. Those plants that did develop had chlorotic leaves and were small.

Vegetation success on the dump slopes was generally much better compared to the level area. Apart from one area of topsoil where results were poor, there was little difference between topsoiled and non-topsoiled dump faces.

Erosion did not appear to be significant of any of the dump faces.

Dump 3

Six species, three grasses and three legumes, were applied in separate rows on both the raw waste and topsoiled waste material on Dump 3. Of these species, sainfoin exhibited the best results. This legume was a highly successful revegetation species in all areas where it was applied. Alfalfa showed moderate success on the topsoil, but mixed results on the non-topsoil.

Tall wheatgrass and streambank wheatgrass had similar success: good abundance on the topsoil and no germination on the raw material. Birdsfoot trefoil did not develop on either topsoil or non-topsoil. Slender wheatgrass indicated slightly poorer results than the other wheatgrasses.

The non-topsoiled area adjacent to the rows showed poor results. Large areas were completely bare of vegetation while some smaller areas had patches of vegetation.

The topsoiled area adjacent to the rows indicated satisfactory results. The major species that have become established were streambank wheatgrass, tall wheatgrass and alfalfa. Dump 3 slopes showed similar results to those obtained on Dumps 1 and 2.

Coal Waste Pile

Although generally patchy on the top, this dump exhibited some areas of good cover of crested wheatgrass. Alfalfa was less abundant and generally smaller and more immature.

Vegetative growth appears somewhat better on the slopes of the coal waste pile where the vegetation (crested wheatgrass) was greener, larger and more abundant. No major erosion was observed on the coal waste though rill erosion is evident on the east side of the dump.

2.3.5 Drill Sites

Extensive exploratory drilling has been carried out in the Hat Creek Valley since 1974. Drill sites and roads have been progressively reclaimed and all disturbed areas were reclaimed by the fall of 1978.

During the spring of 1979, 19 drill sites were randomly selected and the progress of reclamation evaluated. With few exceptions the drill sites have been reclaimed to a satisfactory level.

Details of the sites inspected and photographs of some of the sites are given in the followings. Overall ratings of excellent, good, satisfactory and poor were assigned considering overall vegetation cover; type of vegetation, weeds/agronomics; balance of legume/grass species; condition of plants and plant size and maturity.

Drill Hole	Rating	Comments
DDH 74-29	Satisfactory^{+}	Grass dominated - few legumes, also lots of weeds
DDH 74-44	Good	Good mix of grass and legume

Drill Hole	Rating	Comments
DDH 75-49	Good	Alfalfa and crested wheatgrass dominant; some brome grass; native species invading well.

Drill Hole	Rating	Comments
DDH 76-130/ 76-206	Excellent	Crested wheatgrass and brome grass in excellent condition - clover and native legume, weedy milk vetch, present.

Drill Hole	Rating	Comments
DDH 76-145	Excellent	Almost all grasses - no legume
DDH 76-154	Poor	Some fall rye and slender wheatgrass but mostly weeds
DDH 76-159	Satisfactory⁻	Crested wheatgrass mature and healthy; alfalfa in limited quantities - large quantity of weeds
DDH 76-162	Satisfactory⁻	
DDH 76-251	Excellent	Fall rye dominated. Long term potential may suffer from first year dominance by fall rye.
DDH 76-803	Satisfactory	Alfalfa showed excellent results - good invasion by native species - patchy.

Drill Hole	Rating	Comments
DDH 76-813	Excellent	Smooth brome, crested wheatgrass and stream-bank show excellent results. Alfalfa out-competed.
DDH 76-814	Excellent	Alfalfa was dominant and smooth brome, crested wheatgrass and stream-bank showed excellent results.
RH 77-18, 53, 58	Poor+	Both crested wheatgrass and alfalfa were present but in small quantities. Fall rye was present.

Drill Hole	Rating	Comments
DDH 77 - 39	Satisfactory	Grasses were present but mostly immature - similarly alfalfa.
RH 77-66	Satisfactory	Rotary holes were not reseeded since disturbance is only minor
DDH 78-860	Good+	Grass dominated (crested wheatgrass and smooth brome). Alfalfa was present but plants small in size.

2.4 Trace Element Studies

2.4.1 Introduction

During 1978, samples of soil and vegetation were collected from all test plots at Aleece Lake and selected samples were analysed for trace elements[2]. At that time, only vegetation samples from the colluvium, glacial gravel and fly ash test plots were analysed since the size of the vegetation samples from the other plots was inadequate for test purposes. The 1978 results indicated that trace element concentrations in vegetation grown on colluvium and glacial gravel were similar and generally within ranges normally found in natural environments. In the vegetation grown on the fly ash plot several elements including arsenic, boron, copper, molybdenum and selenium were present at greater concentrations than normally found in natural vegetation. Sampling of soil materials and vegetation at the Aleece Lake test plots for trace element analyses was repeated in the late summer of 1979 on a more comprehensive basis.

2.4.2 Sampling and Analyses

Samples were taken from non-topsoiled sides of the colluvium, glacial gravel, gritstone, bentonitic clay, coal waste and fly ash plots at Aleece Lake. In addition, vegetation samples were collected from the topsoiled portion of the fly ash plot. Soil samples were taken from the colluvium, gritstone and fly ash plots and from nearby natural areas.

The species sampled were restricted to those which have been shown to be particularly useful in revegetation trials, namely, sainfoin, alfalfa, crested wheatgrass, streambank wheatgrass and smooth bromegrass.

A preliminary assessment of the partition of trace elements among the stalk, seed spikes and roots of grass on the coal waste and fly ash plots was made for comparison with a native grass, bluebunch wheatgrass (Agropyron spicatum), found adjacent to the Aleece Lake test site.

Sample collection and handling procedures used in 1979 were identical to those used in 1978. The sampler, wearing plastic gloves, clipped the vegetation using acid washed stainless steel scissors. Each sample was placed in a white paper bag. The vegetation was sampled randomly at several points along the previously used transects across each plot. Sampling was carried out when the vegetation was relatively dry. Soil samples were collected using an acid-washed plastic trowel and placed in plastic bags. All samples were shipped to Vancouver for analysis by Chemex Labs Ltd.

Quality control analyses were performed on certified standards during the analyses and the results are reported in Table 2-4. In all cases the agreement between the actual analytical results and the certified values for the standards was excellent.

Table 2-4 - Trace Element Quality Control Analyses

Element	Certified Value ppm	Actual Analyses ppm
As	10 ± 2	9.5
Be	0.03 ± 0.01	0.04
Cd	0.1 ± 0.01	<0.1
Cu	12 ± 1	12
Cr	2.6 ± 0.3	2.6
Fe	260 ± 20	270
Pb	45 ± 3	43
Hg	0.155 ± 15	0.170
Mo	0.3 ± 0.1	<1
U	0.029 ± 0.005	<0.1
Zn	25 ± 3	26

Vegetation samples were dried at 45°C, weighed and milled to minus 20 mesh. The analytical procedures used were the same as for the prepared soil samples. Some vegetation samples were washed with distilled water prior to drying and milling to determine the affects of washing on the vegetation trace element levels. Trace element levels were also determined on the wash waters. Root samples were washed with distilled water and then each sample was cleaned by allowing it to sit in an ultrasonic bath to dislodge dirt particles. Although this treatment is very effective by larger roots, the masses to tiny rootlets in these samples retained significant quantitites of earth. Siliceous residues were visible following digestion procedures.

Selected vegetation samples were analysed for radionuclides. Pb-210 and Po-210 were measured by their alpha and beta activity respectively following a radiochemical separation. Their activities were measured using a Canberra Model 2200 Low Level Alpha, Beta Analyzer especially designed for environmental samples. This instrument consists of an external proportional counter with an ultra-thin detector window; the counter is completely surrounded by four inches of virgin lead and requires ultrahigh purity P-10 counting gas (90% argon - 10% methane).

(i) Polonium-210: Samples for polonium analysis were digested with nitric and perchloric acids in order to completely destroy all organic matter. The digested solutions were diluted, reduced with ascorbic acid and then heated for two hours in contact with a silver disc. Under these conditions, polonium spontaneously deposits onto the silver disc which is subsequently counted for its alpha activity. The activity of samples were compared with the activity of known amounts of Po-210 carried through the same procedure.

(ii) Lead-210: The beta radiation from Pb-210 is weak and difficult to detect; consequently, the beta radiation from its daughter, Bi-210 is measured. Therefore, samples must be captive for at least thirty days to ensure that the activities of Pb-210 and Bi-210 are in equilibrium. Samples for Pb-210 analysis are digested with nitric and perchloric acids. Bi-210 is dissolved at the same time and is then extracted into chloroform with diethylammonium diethyldithioearbamate. Bismuth is then precipitated as bismuth oxychloride and measured for its beta activity. Standard solutions of Bi-210 are carried through the same procedure for calibration purposes.

Each soil sample was split into four equal fractions. One fraction was reserved and the other three were dried at three different temperatures: room temperature about 22°C, 45°C and 60°C. The samples were then milled and analysed for various trace elements as follows by Chemex Labs Ltd.

(i) Cu, Mo, Pb, Zn, Cd, Fe, Ni, Mn: A sample was wet-ashed with a combination of nitric and perchloric acids and each metal was determined by direct atomic absorption using Varian AA5 or AA6 spectrophotometers. Pb, Ni and Cd were corrected for background absorption.

(ii) As, Se: An aliquot of the above solution was reduced and both elements were analysed as their hybrides via hot vapour flameless atomic absorption using a Varian AA6 spectrophotometer.

(iii) Hg: Samples were digested with nitric and sulphuric acids, potassium permanganate and potassium persulfate. Mercury was reduced and analysed via cold vapour U.V. absorption using a Jarrell Ash spectrophotometer.

(iv) Cr, Co, Be, V: Samples were dry-ashed at 550°C, digested with nitric perchloric and hydrofluoric acids and analysed by direct atomic absorption.

(v) F: Samples were ashed at 550°C using NaOH as an ashing aid. The ash was fused with sodium carbonate, leached with water, buffered and analysed for fluoride with a specific ion electrode.

(vi) Sn: Samples were ashed at 550°C, fused with ammonium iodide, leached, extracted and analysed by atomic absorption.

(vii) Boron: Samples were ashed overnight at 550°C and the ash was dissolved in hydrochloric and nitric acids. The use of normal Pyrex glassware (borosilicate glass) was avoided. Samples were ashed in porcelain and leached in polyethylene containers. The resulting solutions were analysed by Cantest Limited using plasma emission spectroscopy.

(viii) Uranium: An aliquot of the digest solution generated in part (iv) was removed and the uranium separated by solvent extraction into methylisobutylketone with acid-deficient aluminum nitrate. The extracted uranium was then determined by the fluorescence of its fluoride complex using a Turner Model III fluorimeter.

(ix) Thorium was determined by neutron activation analysis. Samples were irradiated in a thermal neutron flux, cooled for a week and then thorium was determined by gamma spectroscopy.

Duplicate analyses were performed wherever sufficient material was available. The duplicate analyses included separate weighing and digestion/fusion in all cases. In no case were duplicate results reported on different aliquots from the same digestion/fusion.

Samples of colluvium, sandstone, fly ash and native soil from near the Aleece Lake plots were analysed by gamma spectroscopy for radionuclides. Gamma spectroscopy analyses were performed by Novatrack Analysts Ltd., a subsidiary of Chemex Labs. The gamma analysis system in use at Novatrack consists of the following equipment:

Detector: A lithium-drifted germanium [Ge(Li)] detector with a resolution of 1.95 KeV at 1.33 MeV, a peak-to-Compton ratio of 45:1 and an efficiency of 17%.

Detector Shield: A lead case of 15 x 15 x 20 inches surrounds the detector. The walls of the cave are 4 inches thick and are lined with 0.02 inches of cadmium and 0.06 inches of copper.

Pre-amplifier: Ortec model 120-4.

Amplifier: Ortec model 572 spectroscopy amplifier and pulse pile-up rejector/live time corrector.

Bias Supply: Ortec model 459.

Bias Filter: Ortec model 119 H.V. filter.

Multichannel Analyser: Ortec model 7044 data acquisition system with a 100MHz 4K ADC and live time clock.

Data Storage: Plessey Model PM-DD/11B hard cartridge disks.

Computer Analysis: DEC Model PDP 11/34 computer system.

Methodology:

Depending on sample size, the sample is weighed into one of three different size containers (50,200 or 500 mls) and placed inside the shield surrounding the detector. The sample was counted for 50,000 seconds (14 hrs) and the gamma rays detected during this counting period were stored in the memory of the multichannel analyser. At the end of the counting period, the spectrum was transferred from the memory of the multichannel analyser to the disk storage units. Analysis of the spectrum was later performed by the computer system.

Assignment of Radionuclide Activities:

Gamma spectroscopy permits the measurement of many of the critical nuclides in the three naturally-occurring radionuclide series. Some of these radionuclides are measured directly by their gamma rays; others which do not emit gamma rays when they disintegrate can be measured indirectly if their half-lives are short in comparison to a longer-lived parent. For example, in the uranium series Ra^{226} and Bi^{214} are measured directly. If the rate of decay of Bi^{214} is found to be identical to the rate of decay of Ra^{226} (within the 2 sigma confidence limits), then one can safely assume that Rn^{222} was in equilibrium with Ra^{226}. Similarly the levels of the Po^{218}, Pb^{214} and Po^{214} can be set equal to the level of Bi^{214} because of the very short half-lives involved. Other radionuclides frequently measured directly include K^{40}, the fission fragments Cs^{137} and Ce^{144} and the light isotope Be^{7}, a product of cosmic ray interactions.

A list of the normal detection limits obtained within gamma spectroscopy is listed in Table 2-5.

Table 2-5 - Gamma Spectroscopy Detection Limits

Detection limits reported here apply to an average granular soil sample weighing about 150 gms and having a volume of 200 mls.

Radionuclide	Type of measurement	Detection Limit (pCi/gm)
U-238	direct	3.0
U-234	direct	20.0
Ra-226	direct	0.02
Rn-222	indirect	0.03
Po-218	indirect	0.03
Pb-214	indirect	0.03
Bi-214	direct	0.03
Po-214	indirect	0.03
Pb-210	direct	4.0
Th-232	indirect	0.03
Ra-228	indirect	0.03
Ac-228	direct	0.03
Th-228	indirect	0.3
Ra-224	direct	0.3
Po-216	indirect	0.03
Pb-212	direct	0.03
Bi-212	indirect	0.03
Po-212	indirect	0.03
Tl-208	indirect	0.03
U-235	direct	0.10
K-40	direct	0.2
Cs-137	direct	0.02
Ce-144	direct	0.05
Be-7	direct	0.10

2.4.3 Results and Discussion

The results of the vegetation trace element analyses of samples from the Aleece Lake test plots are presented in Table 2-6. Where analyses of soil materials was not done in 1979, values obtained in 1978 are shown. The results of analyses of soil materials from Aleece Lake and nearby native soils are also shown in Table 2-6.

Most of the vegetation trace element levels were similar to those found in the 1978 Survey. In all vegetation samples analysed in 1979, where comparable samples were tested in 1978, the levels of cadmium and mercury were significantly greater. The average concentrations of Cd and Hg in the vegetation from the colluvium, glacial gravels and fly ash plots in 1978 were 0.12 mg/kg and 28 µg/kg; in 1979 these were 0.82 mg/hg and 103 µg/kg.

In 1978 the level of cobalt in the sainfoin from the colluvium and glacial gravel plots averaged 0.5 mg/kg about six times the level found in other species growing on the same plots. In 1979, the Co concentrations in the sainfoin were identifical to those found in the other species growing on the same plots.

The average concentration of Co in vegetation grown on the gritstone and bentonitic clay plots was 0.32 mg/kg six times the average concentration in vegetation from the colluvium, glacial gravel and fly ash plots. On the coal waste plot the Co concentration in the vegetation was quite variable ranging from 0.06 mg/kg in the streambank wheatgrass to 0.72 mg/kg in the alfalfa.

TABLE 2-6 TRACE ELEMENT CONCENTRATIONS IN VEGETATION GROWN ON WASTE MATERIALS AT ALEECE LAKE TEST PLOTS

mg/kg	COLLUVIUM						GLACIAL GRAVEL					
	Sainfoin	Alfalfa	Crested Wheatgrass	Streambank Wheatgrass	Smooth Bromegrass	Soil #	Sainfoin	Alfalfa	Crested Wheatgrass	Streambank Wheatgrass	Smooth Bromegrass	Soil ●
As	<0.5	0.5	<0.5	<0.5	.0.5	20	0.5	0.5	0.5	< 0.5	0.5	6
B	128	56	19	18	33	11	113	87	43	30	50	15
Be	0.03	0.05	0.02	<0.01	<0.01	1.5	0.01	0.02	< 0.01	<0.01	<0.01	2.0
Cd	0.6	0.7	0.6	0.7	0.8	0.1	2.6	0.8	0.7	0.6	0.6	<0.2
Cr	0.8	0.8	0.8	0.64	0.64	91	19	2.2	0.8	1.0	1.9	140
Co	0.04	0.04	0.05	0.05	0.04	15	0.08	0.06	0.06	0.08	0.08	14
Cu	8	13	9	8	10	42	9	15	10	8	11	44
F	1.1	1.4	1.9	1.8	1.9	316	1.3	1.5	2.4	3.0	2.7	160
Fe	90	145	133	90	143	2.86%	108	250	175	200	195	3.03%
Pb	2	2	1	1	2	3	1	3	2	2	2	3
Mn	105	48	63	50	58	532	98	80	140	98	178	668
Hg µg/kg	110	105	65	80	95	98	85	65	130	145	95	65
Mo	1	4	1	<1	<1	2	13	7	1	1	1	2
Ni	1	2	<1	1	1	41	1	2	<1	<1	1	59
Se	0.2	<0.2	<0.2	<0.2	<0.2	<1	<0.2	<0.2	<0.2	<0.2	<0.2	< 1
Th	2	< 2	< 2	< 2	< 2	5	<2	2	< 2	< 2	2	10
Sn	<1	<1	<1	<1	< 1	< 1	<1	< 1	<1	< 1	< 1	
U	<0.1	<0.1	<0.1	<0.1	<0.1	1.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5
V	1.2	1.2	1.0	0.8	1.0	119	1.4	1.2	1.0	1.2	1.2	160
Zn	14	18	15	11	12	65	15	20	14	10	12	75

mg/kg	GRITSTONE						BENTONITIC CLAY					
	Sainfoin	Alfalfa	Crested Wheatgrass	Streambank Wheatgrass	Smooth Bromegrass	Soil #	Sainfoin	Alfalfa	Crested Wheatgrass	Streambank Wheatgrass	Smooth Bromegrass	Soil ●
As	0.5	<0.5	0.5	0.5	0.5	7	0.5	0.5	0.5	1.0	1.0	9
B	115	93	25	25	19	6.2	83	83	20	12	15	24
Be	0.03	0.04	0.02	0.06	0.02	1.5	0.03	0.03	0.05	0.03	0.03	2.0
Cd	0.5	0.8	0.6	0.7	0.6	0.1	0.5	0.5	0.8	0.7	0.8	<0.2
Cr	2.4	2.2	2.5	4.7	1.2	97	1.7	1.8	2.8	2.1	1.6	123
Co	0.60	0.39	0.40	0.40	0.23	20	0.12	0.10	0.32	0.28	0.32	16
Cu	12	16	15	14	15	44	10	12	12	12	12	40
F	2.4	2.5	3.8	8.2	3.1	268	2.7	2.5	7.2	6.7	5.4	265
Fe	455	328	580	920	340	2.00%	363	325	865	673	885	2.65%
Pb	2	4	1	1	1	7	2	1	2	2	3	7
Mn	145	80	70	78	98	226	105	60	70	63	128	313
Hg µg/kg	110	105	95	110	115	73	90	85	120	105	100	170
Mo	2	5	4	1	3	2	8	7	1	2	4	2
Ni	2	2	2	2	2	49	1	1	1	1	2	52
Se	0.2	0.3	0.8	0.4	0.7	<1	1.0	1.4	<0.2	<0.2	<0.2	<1
Th	2	2	2	2	< 2	4	2	<2	2	< 2	< 2	30
Sn	< 1	< 1	< 1	<1	< 1	<1	< 1	<1	<1	< 1	<1	
U	<0.1	<0.1	<0.1	0.2	<0.1	1.5	<0.1	<0.1	<0.1	0.1	0.1	<0.5
V	2.6	2.2	2.4	5.0	2.0	121	1.6	1.6	3.8	2.8	2.6	130
Zn	92	107	87	30	45	75	20	20	18	23	23	68

Mean of 1979 Analytical Results ● 1978 Analytical Results

TABLE 2-6 (CONT.) TRACE ELEMENT CONCENTRATIONS IN VEGETATION GROWN ON WASTE MATERIAL AT ALEECE LAKE TEST PLOTS

mg/kg	COAL WASTE						FLY ASH - without topsoil						FLY ASH - with topsoil				
	Sainfoin	Alfalfa	Crested Wheatgrass	Streambank Wheatgrass	Smooth Bromegrass	Soil ●	Sainfoin	Alfalfa	Crested Wheatgrass	Streambank Wheatgrass	Smooth Bromegrass	Soil #	Sainfoin	Alfalfa	Sweet Clover	Crested Wheatgrass	Russian Wildrye and Slender Wheatgrass
As	0.5	0.5	0.5	0.5	0.5	5		1.5	2.0			24	0.5	0.5	0.5	0.5	0.5
B	143	98	21	43	71	17			372			150	122	107	94	157	409
Be	0.01	0.02	0.01	0.01	0.03	1.5			0.04			2.6	0.01	0.02	<0.01	<0.01	<0.01
Cd	0.9	0.8	0.5	0.7	1.1	<0.2		0.1	1.0			0.1	1.2	1.1	0.6	0.9	0.6
Cr	1.8	1.2	0.9	1.1	1.5	105			2.5			124	1.1	1.9	1.1	1.4	1.4
Co	0.38	0.72	0.11	0.06	0.14	11			0.28			10	0.04	0.04	0.04	0.04	0.10
Cu	10	17	10	10	17	55		21	23			454	11	19	11	11	12
F	1.4	1.4	2.4	2.4	3.0	133			1.2			107	1.4	1.4	1.3	2.6	2.2
Fe	180	143	143	140	230	1.60%		420	428			2.63%	150	243	95	278	288
Pb	3	2	2	3	3	6		2	3			3	2	3	2	2	1
Mn	200	153	95	88	105	140		65	28			262	145	53	50	68	38
Hg µg/kg	85	80	75	80	85	80			115			60	120	130	115	105	90
Mo	<1	1	<1	2	2	4		14	11			10	10	8	8	5	10
Ni	2	2	1	<1	1	45		2	1			56	1	1	2	1	1
Se	<0.2	<0.2	<0.2	<0.2	<0.2	<1		0.2	0.4			<1	<0.2	<0.2	<0.2	<0.2	0.4
Th	<2	2	<2	2	<2	10		---	<2			9	<2	<2	<2	<2	<2
Sn	<1	<1	<1	<1	<1			---	<1			<1	<1	<1	<1	<1	<1
U	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5		---	0.1			1.3	<0.1	0.1	<0.1	0.1	0.1
V	1.4	1.2	1.4	1.2	1.0	150			6.2			257	1.2	2.0	0.8	1.8	1.8
Zn	55	54	40	16	30	57		50	19			39	48	26	27	9	11

Mean of 1979 Analytical Results ● 1978 Analytical Results

The concentration of boron found in the legume species was greater than found in the other species at all of the Aleece Lake plots.

Selected vegetation samples were washed by rinsing in distilled water to examine the effects of dirt adhering to the plants. A comparison of the trace element concentrations found in samples of washed and unwashed vegetation from the fly ash plot is shown in Table 2-7.

In most cases washing of the vegetation samples before sample preparation and analyses for trace elements did not significantly alter the analytical results. The results, however, are inconsistent and probably influenced by the variability due to sampling selection and preparation. Washing the samples taken from the fly ash plot with no topsoil reduced the trace element concentrations in 57 percent of the tests, produced no change in 33 percent of the plots and increased the level of the trace element in 10 percent of the tests. Washing of the vegetation samples from the half of the plot with topsoil reduced the trace element levels in 22 percent of the tests, caused no change in 47 percent and increased the trace element concentrations in 32 percent of the tests.

The wash water from these comparative tests was also analysed for selected elements and the results are shown in Table 2-8.

Table 2-7 - Comparison of Trace Element Levels in Washed and Unwashed Vegetation Samples - Fly Ash Plot

mg/hg	Alfalfa				Crested Wheatgrass				Sainfoin	
	Topsoil		No Topsoil		Topsoil		No Topsoil		Topsoil	
	W	U	W	U	W	U	W	U	W	U
As	0.5	0.5	1.0	1.5	0.8	0.5	1.0	2.0	0.5	0.5
Be	0.2	0.2	-	-	< 0.01	<0.01	0.03	0.04	<0.01	<0.01
B	129	107	-	-	189	157	287	372	156	122
Cd	1.1	1.1	0.1	0.1	0.9	0.9	0.9	1.0	1.15	1.2
Cr	1.2	1.9	-	-	1.2	1.35	2.2	2.5	0.95	1.05
Co	0.04	0.04	-	-	0.08	0.04	0.22	0.28	0.04	0.04
Cu	15	19	20	21	12	11	19	23	12	11
F	1.6	1.4	-	-	2.6	2.2	1.3	1.2	1.2	1.4
Fe	238	243	390	420	285	278	325	430	185	150
Pb	2	3	2	2	2	3	3	3	2	2
Mn	60	53	50	65	68	68	28	28	185	145
Hg µg/hg	120	130	-	-	110	105	120	115	115	120
Mo	8	7	.13	14	5.5	4.5	9	11	7	10
Ni	1	1	2	2	1	1	1	1	1	1
Se	<0.2	<0.2	<0.2	0.2	<0.2	<0.2	<0.2	0.4	<0.2	<0.2
Th	<2	<2	-	-	<2	<2	<2	2	<2	<2
Sn	<1	<1	-	-	<1	<1	<1	<1	<1	<1
U	0.1	0.1	-	-	0.1	0.1	0.1	0.1	0.1	0.1
V	1.6	2.0	-	-	2.0	1.8	4.4	6.2	1.2	1.2
Zn	26	26	38	50	10.5	9	16	19	54	48

W - sample washed

U - sample unwashed

Table 2-8 - Analyses of Vegetation Wash Waters

mg/kg	Alfalfa		Crested Wheatgrass		Sainfoin
	Topsoil	No Topsoil	Topsoil	No Topsoil	Topsoil
Cd	<0.5	<0.5	<0.5	<0.5	<0.5
Cu	1.5	7.5	0.35	2.0	0.52
Fe	92	27	48	100	20
Pb	0.75	5.0	0.18	0.30	0.52
Hg	<0.025	<0.025	<0.025	<0.025	<0.025
Zn	1.8	8.3	0.63	0.66	1.3
Weight of material washed - g	21.6	1.2 *	39.9	35.0	23.1

* data suspect.

The quantity of each element found in the wash water exceeded the difference found between the washed and unwashed samples in over 50 percent of the tests. The accuracy of these tests is somewhat limited by the small size of the samples that were available.

The trace element concentrations in the Aleece Lake soil materials and native soils were also generally similar to levels found in the 1978 survey as shown in Table 2-9. Concentrations of fluoride and uranium were consistently lower in 1979 than in 1978 in the colluvium, glacial gravel and fly ash plots but showed no change in the native soils. In the colluvium and glacial gravel plots the concentration of thorium was four or five times the levels found in 1978.

TABLE 2 - 9 TRACE ELEMENTS CONCENTRATIONS IN HAT CREEK SOIL MATERIALS

MATERIAL	COLLUVIUM					GRITSTONE					FLY ASH					NATIVE SOIL				REGIONAL SOIL	
Sample Date	1979				1978	1979				1978	1979				1978	1979				1979	
Drying Temp. 0°C / Element mg/kg	Room Temp	45	60	Mean	55-60	Room Temp	45	60	Mean	55-60	Room Temp	45	60	Mean	55-60	Room Temp	45	60	Mean	Mean	Range
As	19	20	20	20	10	7	8	6	7	6	27	23	22	24	16	2	2	3	2	5.0	2.0-10.5
B	12	9.9	10	11	11	6.6	6.8	5.3	6.2	8.8	151	147	151	150	178	3.6	4.1	4.2	4.0	5.6	2.2-10.5
Be	1.5	1.5	1.4	1.5	2.0	1.4	1.5	1.5	1.5	2.0	2.6	2.6	2.7	2.6	2.0	1.6	1.7	1.7	1.7	1.0	0.3-1.7
Cd	0.1	0.1	0.1	0.1	<0.2	0.2	0.1	0.1	0.1	<0.2	0.1	0.1	0.2	0.1	<0.2	0.1	0.1	0.1	0.1	<1.5	<0.1-6.3
Cr	102	86	84	91	125	94	98	99	97	133	130	124	117	124	128	142	135	143	140	91.6	36.5-173
Co	15	15	15	15	15	20	19	20	20	18	10	11	10	10	10	13	12	13	13	14	5-28
Cu	42	42	42	42	39	44	44	44	44	46	453	460	450	454	530	30	30	28	29	28	18-54
F	313	305	330	316	203	258	273	273	268	200	108	108	105	107	20	218	218	220	219	195	58-445
Fe%	2.80	2.88	2.90	2.86	2.63	2.00	2.00	2.00	2.00	2.33	2.60	2.65	2.63	2.63	2.30	3.10	2.95	2.98	3.01	2.56	1.15-5.18
Pb	3	3	2	3	4	8	6	8	7	6	2	4	2	3	2	2	2	2	2	10	4-18
Mn	525	535	535	532	533	225	223	230	226	330	258	260	268	262	288	678	695	680	684	-	-
Hg µg/kg	90	100	105	98	90	65	75	80	73	95	65	55	60	60	50	40	50	55	48	98	<10-170
Mo	2	2	1	2	2	3	2	2	2	2	10	11	10	10	5.5	2	1	1	1	1.4	<1-2.5
Ni	40	43	40	41	45	50	45	51	49	51	52	59	57	56	53	32	30	28	30	-	-
Se	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-
Th	5	5	5	5	20	4	4	4	4	20	9	10	9	9	10	4	4	5	4	-	-
Sn	<1	<1	<1	<1		<1	<1	<1	<1		<1	<1	<1	<1		<1	<1	<1	<1	<1	<1-1
U	1.3	1.3	1.8	1.5	0.5	1.5	1.5	1.5	1.5	0.5	1.0	1.5	1.5	1.3	0.5	0.5	0.5	0.5	0.5	0.75	<0.5-2.3
V	125	118	113	119	135	123	120	120	121	145	253	258	260	257	270	95	103	105	101	113	50-197.5
Zn	64	66	66	65	75	74	75	75	75	82	36	46	35	39	50	92	82	72	82	145	60-206

Trace elements concentrations in the colluvium and glacial gravel were similar to those in the native soils near to the Aleece Lake plots and to the soils in the Hat Creek region which were collected as part of the environmental trace element programme (Section 5.0 of this report). Levels of arsenic were greater in all of the Aleece Lake soil materials than in the native soils. In the fly ash soil material, the levels of boron, copper, molybdenum, uranium and thorium were higher while fluoride and manganese levels were lower than in the native and regional soils.

Drying of the soil material samples at the three different temperatures had no significant effects on the analytical results. In fact, more volatile elements, such as fluoride and mercury, consistently showed higher results when dried at the highest temperature, 60°C, the opposite of what would be expected.

Trace element concentrations were determined in the spikes, stalk and root portions of selected plants grown on the no topsoil half of the fly ash and coal waste plots at Aleece Lake and in a similar native grass species grown in native soils near the Aleece Lake plots. These results are presented in Table 2-10. Although the roots were washed with distilled water and then ultrasonically cleaned, there remained a significant quantity of earth attached to the fine root mass. Siliceous residues were visible following the acid digestion procedures of the analyses. Thus the levels of trace elements in the roots may be somewhat different than reported here due to this retained earth. In general, the root and stalk portions of the plants contained higher levels of trace elements than the spikes and above ground plant portions. Only boron tended to be more concentrated in the above ground plant portions.

Table 2-10 - Analyses of Selected Plant Parts

mg/kg	Fly Ash - No Topsoil		Coal Waste - No Topsoil				Native Soils		
	Crested Wheatgrass		Streambank Wheatgrass				Bluebunch Wheatgrass		
	Above Ground	Roots	Above Ground	Spikes	Stalks	Roots	Spikes	Stalks	Roots
As	2.0	3.5	0.5	0.5	3.0	3.0	0.5	0.5	2.0
Be	0.04	0.32	0.01	0.01	0.31	0.33	0.01	0.17	0.31
B	372	67	43	18	30	11	-	11	9.4
Cd	1.0	2.3	0.7	0.6	0.6	0.9	0.9	0.95	1.0
Cr	2.5	14.7	1.1	1.85	14.4	14.2	1.3	6.7	11.7
Co	0.28	1.7	0.06	0.13	1.3	1.6	0.04	0.86	1.5
Cu	23	144	10	13	20	27	11	17.5	28
F	1.2	19	2.4	2.6	20	22	2.2	17	17.5
Fe	428	3500	140	108	2500	4200	200	2900	5500
Pb	3	2	3	2	2	2	2	3.5	5
Mn	28	75	88	58	73	105	30	100	180
Hg µg/kg	115	140	80	60	95	125	90	65	100
Mo	11	13	2	<1	<1	<1	1	<1	<1
Ni	1	14	<1	1	6.5	8	1	3.5	7.5
Se	0.4	0.5	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Th	<2	2	2	<2	2	<2	-	<0.2	<0.2
Sn	<1	<1	<1	<1	<1	<1	-	<1	<1
U	0.1	0.7	<0.1	<0.1	0.5	0.7	<0.1	0.2	0.3
V	6.2	30	1.2	1.6	33	33	1.2	12	22
Zn	19	35	16	29	29	52	17	24.5	47

Four vegetation samples were analysed for radionuclides Pb-210 and Po-210. These results are presented in Table 2-11.

Table 2 - 11 - Radionuclide Analyses

Sample	Radionuclides - pCi/g	
	Pb-210	Po-210
Fly Ash - no topsoil		
- crested wheatgrass (washed)	0.2	0.06±0.05
Colluvium - no topsoil		
- alfalfa	0.2±0.2	0.07±0.04
- crested wheatgrass	0.3±0.2	0.10±0.05
Native grass - Lower Hat Creek (May 1979)	1.5±0.2	1.3±0.1
Native grass - Lower Hat Creek (May 1979)	0.8±0.2	0.7±0.1
Native grass - Lower Hat Creek (May 1979)	0.9±0.2	0.7±0.1

The analysts indicate that activities of Pb-210 and Po-210 are essentially in equilibrium within experimental uncertainty for these samples. The native grasses showed higher levels than the vegetation growing on the Aleece Lake plots. All of the results are typical of levels found in natural vegetation.

The results of the gamma spectroscopy analyses are presented in Table 2-12.

Table 2 - 12 - Results of Gamma Spectroscopy Radionuclide Analyses (pCi/g)

Radionuclide	Colluvium	Sandstone	Fly Ash	Native Soil
U-238	0.80 ± 0.40	1.90 ± 0.80	2.10 ± 0.60	0.70 ± 0.40
TH-234	0.80 ± 0.40	1.90 ± 0.80	2.10 ± 0.60	0.70 ± 0.40
RA-226	2.00 ± 0.60	3.30 ± 0.70	4.00 ± 1.00	2.40 ± 0.80
PB-214	1.50 ± 0.50	2.40 ± 0.80	3.70 ± 0.80	1.40 ± 0.60
BI-214	1.50 ± 0.50	2.40 ± 0.80	3.70 ± 0.80	1.40 ± 0.60
PO-214	1.50 ± 0.50	2.40 ± 0.80	3.70 ± 0.80	1.40 ± 0.60
PB-210	1.60 ± 0.60	2.40 ± 0.90	3.10 ± 0.80	3.00 ± 1.00
AC-228	0.92 ± 0.05	1.60 ± 0.20	2.25 ± 0.15	1.25 ± 0.20
RA-228	0.92 ± 0.05	1.60 ± 0.20	2.25 ± 0.15	1.25 ± 0.20
TH-228	0.92 ± 0.05	1.60 ± 0.20	2.25 ± 0.15	1.25 ± 0.20
PB-212	1.03 ± 0.06	1.65 ± 0.20	2.45 ± 0.15	1.25 ± 0.20
BI-212	1.03 ± 0.06	1.65 ± 0.20	2.45 ± 0.15	1.25 ± 0.20
PO-216	1.03 ± 0.06	1.65 ± 0.20	2.45 ± 0.15	1.25 ± 0.20
PO-212	0.70 ± 0.10	1.10 ± 0.20	1.65 ± 0.10	0.80 ± 0.20
TL-208	0.30 ± 0.10	0.55 ± 0.20	0.80 ± 0.10	0.40 ± 0.10
U-235	<0.10	<0.10	<0.10	<0.10
K-40	22.10 ± 0.80	33.00 ± 6.00	16.10 ± 0.80	31.70 ± 1.20
CS-137	0.09 ± 0.03	0.08 ± 0.03	<0.05	0.93 ± 0.03
CE-144	<0.10	<0.20	<0.10	<0.20
BE-7	<0.10	<0.10	<0.10	<0.10

3.0 WATER QUALITY MONITORING

3.1 Introduction

During 1977, water quality monitoring was started to provide background data and to monitor possible effects of mining activities on regional surface water and groundwater quality. Samples from several surficial watercourses and groundwater wells in the Hat Creek area have been collected and analysed since 1977. This monitoring programme was continued in 1978 and again in 1979 to obtain more background water quality information. In 1979 the surface water quality monitoring programme was expanded. This included more frequent sampling at two new locations and a study, which was initiated in September 1979, to establish background coliform levels in Hat Creek where it passes through coal deposit No. 1. Data was also compiled on rain runoff in 1979.

The temperature of Hat Creek could be significantly increased by the mine and powerplant development. During the summers of 1978 and 1979, daily temperature data were collected to establish background temperature characteristics for Hat Creek.

During the Bulk Sample Program in 1977, two waste materials, low grade coal and coaly waste, were piled on specially prepared areas near Trench A to enable the collection of leachates from the piles to be made. In the fall of 1978, leachate samples were collected on a daily basis to study the water that had percolated through the piles. Daily collections were continued in 1979 to compile additional information.

3.2 Surface Water

In 1978, surface waters were sampled to compare with data collected in 1977. In June 1979, more samples were taken at the Hat Creek stations (1) and (3) about 0.5 km above and below Trench B, and at the Medicine Creek station about 3 km upstream of its confluence with Hat Creek. New sampling stations were established at Ambusten Creek and Houth Creek at their confluence with Hat Creek.

The water samples were collected by Acres Consulting Services Ltd. and sent to Beak Consultants Limited, Vancouver for analyses. Some duplicate samples were also sent to the B.C. Hydro Research Laboratory, Vancouver, for analyses. Samples were preserved and filtered as required in the field and shipped in plastic bottles in coolers. A complete description of the sampling, preservation and analytical methods is given in the reports entitled Hat Creek Project, Detailed Environmental Studies, Water Resources Subgroup, prepared for B.C. Hydro by Beak Consultants Limited, May 1978.[5]

The results of the surface water quality monitoring programme are presented in Tables 3-1 to 3-5. The results are consistent with the 1977 and 1978 data.

Due to the poor snowfall, the flow rates of the surface waters during the spring of 1979 remained relatively low compared to the previous years. During the spring freshet, samples were collected from three sites to study suspended solids concentrations. From 13 May to 18 June 1979, samples were collected from Hat Creek at its confluence with Anderson Creek; from Medicine Creek about 0.6 km from its confluence with Hat Creek;

TABLE 3-1 - SURFACE WATER QUALITY ANALYSES - HAT CREEK STATION #1

Parameter / Dissolved Total CATIONS (Mg/l) \ Date	HAT CREEK STATION No. 1																	B.C.Hydro Lab.			
	26/4/77	11/5/77	24/5/77	8/6/77	22/6/77	5/7/77	20/7/77	4/8/77	14/9/77	19 / 10 / 77		29 / 11 / 77		1 / 5 / 78		7 / 6 / 78		7 / 6 / 78		23 / 8 / 78	
	Diss.	Diss.	Diss.	Diss.	Diss.	Diss.	Diss.	Diss.	Diss.	Diss.	Total	Diss.	Total	Diss.	Total	Diss.	Total	Diss.	Total	Diss.	Total
Aluminum (Al)	*	*	*	*	*	*	*	*	*	<0.1	0.060	0.077	0.080	0.030	7.8	0.051	7.2	0.04	15.8	0.008	0.13
Arsenic (As)	*	*	*	*	*	*	*	*	*	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.05		<0.005	<0.005
Cadmium (Cd)																					
Calcium (Ca)	42	59	60	37	57	60	60	56	58	64	64	60		45	52	24	29	24.5	32.8	65	65
Chromium (Cr)	*	*	*	*	*	*	*	*	*	<0.010	<0.010	<0.010	<0.010	<0.010	0.020	<0.010	<0.010	<0.01	0.09	<0.010	<0.010
Copper (Cu)	*	*	*	*	*	*	*	*	*	<0.005	<0.005	<0.005	<0.005	<0.005	0.033	<0.005	0.024	0.016	0.024	<0.005	<0.005
Iron (Fe)	0.018	0.019		0.029	0.022	0.020	0.014	0.014	0.030	0.023	0.065	0.031	0.074	0.057	12	0.076	8.6	0.083	15.2	0.022	0.17
Lead (Pb)																					
Lithium (Li)	0.010	0.005	0.004	0.003	0.004	0.004	0.005	0.004	0.002	0.004	0.004	0.005	0.005	0.004	0.006	0.001	0.004	0.001	0.006	0.004	0.004
Magnesium (Mg)	13	21	21	12	15	22	19	17	19	18	18	6		19	21	6.0	7.5	8.1	11.3	21	21
Mercury (Hg)(μg/l)	*	*	*	*		*	*	0.25	*	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	0.32			0.3	0.35
Molybdenum (Mo)																					
Nickel (Ni)														0.014	0.054	<0.010	0.018	0.012	0.028		
Potassium (K)																		1.2	2.08		
Selenium (Se)	*	*	0.005	*	0.003	*	*	*	*	<0.003		<0.003		<0.003	<0.003	<0.003	<0.003			<0.003	<0.003
Sodium (Na)	14	24	25	15	21	20	22	23	22	21	22	23		17	18	7.4	7.4	7.0	9.48	26	28
Strontium (Sr)	0.24	0.30	0.30	0.13	0.18	0.31	0.24	0.25	0.29	0.24	0.24	0.25	0.28	0.26	0.27	0.095	0.14			0.32	0.37
Vanadium (V)	*	0.002	0.011	*	*	0.001	0.001	0.006	0.006	0.003	0.003	<0.003	<0.003	<0.003	0.019	0.002	0.021	<0.002	<0.002	0.003	0.003
Zinc (Zn)	0.008	0.005	*	0.010	*	*	0.024	0.036	0.006	<0.005	0.007	0.019	<0.005	0.007	0.055	0.012	0.031	0.049	0.061	0.006	0.006
Manganese (Mn)										0.011	0.012	0.010	0.012					0.01	0.36		
Silica (Si as SiO_2)																		11.9	200.9		
Titanium (Ti)																		<0.1	1.25		
Barium (Ba)																		0.13	0.14		

* Denotes <MDC

TABLE 3-1 (continued)

HAT CREEK STATION #1

Parameter (Dissolved, Total) CATIONS (Mg/l) / Date of Sampling	13/6/79 Diss.	13/6/79 Total
Aluminum (Al)	0.044	
Arsenic (As)		<0.005
Cadmium (Cd)	<0.005	
Calcium (Ca)	56	
Chromium (Cr)	<0.01	
Copper (Cu)	<0.005	
Iron (Fe)	<0.01	
Lead (Pb)	<0.01	
Lithium (Li)	0.004	
Magnesium (Mg)	20	
Mercury (Hg)(ug/l)	<0.25	<0.25
Molybdenum (Mo)	0.002	
Nickel (Ni)	<0.01	
Potassium (K)	3.2	
Selenium (Se)	<0.003	
Sodium (Na)	27	
Strontium (Sr)	0.29	
Vanadium (V)	0.003	
Zinc (Zn)	<0.005	
Manganese (Mn)	0.02	

TABLE 3-1 (continued)

Date (Mg/l) Parameter Dissolved Total ANIONS, ORGANIC, CALCULATED VALUES	26/4/77	11/5/77	24/5/77	8/6/77	22/6/77	5/7/77	20/7/77	4/8/77	14/9/77	HAT CREEK STATN No. 1 19 / 10 / 77		29 / 11 / 77		1 / 5 / 78		7 / 6 / 78		B.C.Hydro Lab. 7 / 6 / 78		23 / 8 / 78	
										Diss.	Total	Diss.	Total	Diss.	Total	Diss.	Total	Diss.	Total	Diss.	Total
Boron (B)	*	0.2	*	*	0.1	*	*	*	*	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.10	<0.10	0.053		<0.10	<0.10
Chloride (Cl)	0.78	1.2	1.0	0.63	0.88	0.99	1.0	1.3	1.2		0.78		0.92		1.3		0.30		0.32		1.4
Fluoride (F)	0.088	0.120	0.107	0.090	0.107	0.112	0.118	0.118	0.101		0.059		0.059		0.121		0.071				0.12
Sulfate (SO_4)	41	56	65	34	44	68	52	45	41		51		47		50		23		9.3		70
Total-Kjeldahl-Nitrogen (N)																					
Nitrate-Nitrogen (NO_3 - N)																					
Nitrite-Nitrogen (NO_2 - N)																					
Total-Orthophosphate-Phosphorus (P)																					
Dissolved-Total-PO_4-Phosphorus (P)	Diss. 0.030	Diss. 0.056	Diss. 0.054	Diss. 0.051	Diss. 0.083	Diss. 0.049	Diss. 0.032	Diss. 0.045	Diss. 0.049	0.026		0.024		0.041		0.029		<0.05		0.027	
COD																					
TOC	15	10	17	19	24	34	26	17	6		5		14		33		10				6
Phenol																					
Total Hardness($CaCO_3$)	158	234	236	142	204	240	228	210	223		234		216		191		84.5		88.0		249
Total Alkalinity($CaCO_3$)	149	220	230	149	198	236	243	250	234		235		220		197		87		80		240
BOD_5																					
D.O.																					
% Saturation																					

* Denotes <NDC

TABLE 3-1 (continued)

HAT CREEK STATION NO.1

Date of Sampling / (mg/L) Parameter Diss. (D), Total (T) ANIONS, ORGANIC, CALCULATED VALUES	13/6/79 Diss.	Total																			
Boron (B)	<0.1																				
Chloride (Cl)	2.4																				
Fluoride (F)	0.099																				
Sulfate (SO_4)	55																				
Total-Kjeldahl-Nitrogen (N)																					
Nitrate-Nitrogen (NO_3 -N)	0.03																				
Nitrite-Nitrogen (NO_2 -N)	<0.005																				
Total-Orthophosphate-Phosphorus (P)																					
Dissolved-Total PO_4 Phosphorus (P)	0.042																				
COD																					
TOC	10																				
Phenol																					
Total Hardness ($CaCO_3$)	222																				
Total Alkalinity ($CaCO_3$)		232																			
BOD_5																					
D.O.																					
% Saturation																					

TABLE 3-1 (continued)

Date / Parameter Dissolved Total PHYSICAL DATA (Mg/1)	HAT CREEK STATION No. 1																				
	26/4/77	11/5/77	24/5/77	8/6/77	22/6/77	5/7/77	20/7/77	4/8/77	14/9/77	19/10/77	29/11/77	1/5/78	7/6/78	BCH Lab. 7/6/78	23/8/78	13/6/79					
pH (units)	7.9	8.5	8.4	8.3	8.4	8.4	8.5	8.6	8.4	8.3	8.2	8.4	8.0	8.1	8.3	8.5					
Specific Conductance (μmhos/cm @ 25° C)	370	490	520	350	440	547	520	520	508	506	485	436	190	170	557	516					
True Color (Pt-Co Units)																					
Turbidity (NTU)															1.8						
Temperature (°C)																					
Total residue	323	362	383	288	313	383	351	353	359	327	320	567	354	224	385	360					
Filtrable residue	253	360	367	253	306	378	349	353	346	324	316	286	138	158	381	352					
Non-filtrable residue	70	2	16	35	7	5	2	<1	13	3	4	281	216	65.5	4	8					
Fixed total residue																					
Fixed filtrable residue																					
Fixed non-filtrable residue																					

TABLE 3-2 - SURFACE WATER QUALITY ANALYSES - HAT CREEK STATION #3

Parameter (mg/L) Dissolved (D), Total (T) - CATIONS / Date of Sampling	HAT CREEK STATION NO. 3 26/4/77	11/5/77	24/5/77	8/6/77	22/6/77	5/7/77	20/7/77	3/8/77	14/9/77	19/10/77 Diss.	19/10/77 Total	29/11/77 Diss.	29/11/77 Total	1/5/78 Diss.	1/5/78 Total	7/6/78 Diss.	7/6/78 Total	23/8/78 Diss.	23/8/78 Total	13/6/79 Diss.	13/6/79 Total
Aluminum (Al)	*	*	*	*	*	*	0.015	0.25	*	<0.010	0.032	<0.010	0.020	0.039	4.3	0.067	8.9	0.008	0.27	0.005	
Arsenic (As)	*	*	*	*	*	*	*	*	*	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	
Cadmium (Cd)																				<0.005	
Calcium (Ca)	45	60	59	39	57	61	60	57	57	65	65	60		47	49	24	31	65	65	58	
Chromium (Cr)	*	*	*	*	*	*	*	*	*	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.01	
Copper (Cu)	*	*	*	*	*	*	*	*	*	<0.005	<0.005	<0.005	<0.005	<0.005	0.017	<0.005	0.032	<0.005	<0.005	0.005	
Iron (Fe)	0.012	0.032	0.032	0.021	0.028	0.018	0.010	0.010	0.026	0.025	0.064	0.030	0.056	0.064	6.0	0.074	11	0.023	0.29	0.03	
Lead (Pb)																				<0.01	
Lithium (Li)	0.011	0.005	0.004	0.004	0.004	0.005	0.005	0.005	0.003	0.004	0.004	0.004	0.004	0.003	0.004	0.001	0.004	0.004	0.004	0.004	
Magnesium (Mg)	15	20	21	12	15	21	19	17	18	18	18	15		19	20	6.0	8.5	20	20	20	
Mercury (Hg)(ug/l)	*	*	*	*	*	*	*	*	*	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	0.35	0.37	0.30	0.45
Molybdenum (Mo)																				0.002	
Nickel (Ni)														0.015	0.033	0.010	0.023			<0.01	
Potassium (K)																				3.3	
Selenium (Se)	0.004	0.004	*	*	0.003	*	*	*	0.005	<0.003		<0.003		<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	
Sodium (Na)	14	24	25	14	19	20	21	23	22	21	21	23		18	20	6.2	6.2	26	27	28	
Strontium (Sr)	0.26	0.29	0.31	0.20	0.18	0.34	0.24	0.26	0.30	0.24	0.24	0.23	0.28	0.26	0.28	0.10	0.16	0.36	0.37	0.31	
Vanadium (V)	*	0.001	*	*	*	0.003	*	0.004	*	0.006	0.006	<0.003	<0.003	<0.003	0.012	0.002	0.027	0.003	0.003	0.004	
Zinc (Zn)	*	0.008	0.011	0.005	0.021	*	0.084	0.010	0.007	0.010	0.010	0.022	0.010	0.008	0.029	0.008	0.071	0.007	0.010	0.007	
Manganese (Mn)										<0.005	0.007	<0.010	0.010							0.01	

* Denotes <MDC

TABLE 3-2 (continued)

Parameter (mg/L) Diss. (D), Total (T) ANIONS, ORGANIC, CALCULATED VALUES / Date of Sampling	HAT CREEK STATION NO. 3 26/4/77	11/5/77	24/5/77	8/6/77	22/6/77	5/7/77	20/7/77	3/8/77	14/9/77	19/10/77 Diss.	19/10/77 Total	29/11/77 Diss.	29/11/77 Total	1/5/78 Diss.	1/5/78 Total	7/6/78 Diss.	7/6/78 Total	23/8/78 Diss.	23/8/78 Total	13/6/79 Diss.	
Boron (B)	*	*	*	*	*	*	*	*	*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.10	<0.10	<0.1	
Chloride (Cl)	0.95	1.3	1.3	0.70	0.85	0.94	0.85	1.1	0.88		0.82		0.92		1.4		0.42		1.5	1.4	
Fluoride (F)	0.088	0.107	0.113	0.082	0.117	0.108	0.120	0.122	0.091		0.086		0.079		0.123		0.078		0.12	0.107	
Sulfate (SO_4)	35	56	64	34	42	66	50	41	41		52		45		50		23		67	56	
Total-Kjeldahl-Nitrogen (N)																					
Nitrate-Nitrogen (NO_3 -N)																				0.03	
Nitrite-Nitrogen (NO_2 -N)																				<0.005	
Total-Orthophosphate-Phosphorus (P)																					
Dissolved-Total PO_4 Phosphorus (P)	0.030	0.045	0.062	0.052	0.078	0.055	0.038	0.048	0.042	0.029		0.029		0.006		0.024		0.025		0.038	
COD																					
TOC	19	6	16	20	32	28	28	12	5		12		16		22		12		2		7
Phenol																					
Total Hardness($CaCO_3$)	174	232	234	147	204	239	228	212	216		236		212		226		84.6		245		227
Total Alkalinity($CaCO_3$)	158	219	230	153	196	237	247	248	229		237		223		227		91		239		231
BOD_5																					
D.O.																					
% Saturation																					
* Denotes <MDC																					

TABLE 3-2 (continued)

HAT CREEK STATION NO. 3

Parameter \ Date of Sampling — PHYSICAL DATA (mg/L)	26/4/77	11/5/77	24/5/77	8/6/77	22/6/77	5/7/77	20/7/77	3/8/77	14/9/77	19/10/77	29/11/77	1/5/78	7/6/78	23/8/78	13/6/79
pH (units)	7.9	8.5	8.4	8.3	8.4	8.6	8.5	8.6	8.4	8.4	8.2	8.4	7.9	8.3	8.5
Specific Conductance (µmhos/cm @ 25° C)	380	410	530	360	446	540	530	520	498	516	497	444	200	552	520
True Color (Pt-Co Units)															
Turbidity (NTU)														2.8	
Temperature (°C)															
Total residue	336	355	385	270	308	378	352	362	337	329	331	412	447	383	355
Filtrable residue	258	350	367	236	300	371	349	360	328	329	328	296	152	376	345
Non-filtrable residue	78	5	18	34	8	7	3	2	9	<1	3	116	295	7	10
Fixed total residue															
Fixed filtrable residue															
Fixed non-filtrable residue															

TABLE 3-3 - SURFACE WATER QUALITY ANALYSES - MEDICINE CREEK

(mg/L) Parameter Dissolved (D), Total (T) CATIONS / Date of Sampling	MEDICINE CREEK							BCH Lab		
	21/5/77 D	27/7/77 D	6/8/77 D	13/9/77 D	18/10/77 D	27/4/78 D	6/6/78 D	6/6/78 D	21/8/78 D	11/6/79 D
Aluminum (Al)	<0.010									
Arsenic (As)	<0.005									
Cadmium (Cd)	<0.005									
Calcium (Ca)	61	57	61	58	60	31	29	28.5	60	62
Chromium (Cr)	<0.010									<0.01
Copper (Cu)	<0.005									
Iron (Fe)	0.021									0.04
Lead (Pb)	<0.010									
Lithium (Li)	0.003									
Magnesium (Mg)	29	20	21	24	23	19	10	12.5	23	23
Mercury (Hg) (µg/l)	0.5									
Molybdenum (Mo)	<0.020									
Nickel (Ni)										
Potassium (K)		2.5	2.2	2.3	1.6	2.2	0.81	0.7	1.5	
Selenium (Se)	<0.003									
Sodium (Na)	14	12	12	11	9.0	11	2.5	2.5	13	10
Strontium (Sr)	0.44									
Vanadium (V)	<0.005									
Zinc (Zn)	0.009									<0.005
Silica (SiO_2) Dissolved Total		0.5	2.0	5.2	10.7	12.1	10.9		12.95	13
Silica Dissolved Molybdate Reactive						11.9	10.8		12.0	13

TABLE 3-3 (continued)

Parameter (mg/L) Diss. (D), Total (T) ANIONS, ORGANIC, CALCULATED VALUES / Date of Sampling	MEDICINE CREEK							RCH Lab		
	21/5/77 D	27/7/77 D	6/8/77 D	13/9/77 D	18/10/77 D	27/4/78 D	7/6/78 D	7/6/78 D	21/8/78 D	11/6/79 D
Boron (B)	<0.1									
Chloride (Cl)	0.50	0.35	0.20	0.26	0.16	0.80	0.24	0.35	0.44	0.5
Fluoride (F)	0.122									
Sulfate (SO_4)	40	20	18	15	16	18	13	6.3	23	13
Total-Kjeldahl-Nitrogen (N)	0.26									
Nitrate-Nitrogen (NO_3 -N)	0.04									
Nitrite-Nitrogen (NO_2 -N)	<0.0010									
Total-Orthophosphate-Phosphorus (P)	0.010									
Dissolved-Total PO_4 Phosphorus (P)										
COD	10									
TOC	27					22	20		5	10.9
Phenol	<0.002									
Total Hardness ($CaCO_3$)	272					156	114	118	245	250
Total Alkalinity ($CaCO_3$)	188	255	263	262	256	169	111	110	260	268
BOD_5										
D.O.										
% Saturation										
Phenolphthalein Alkalinity ($CaCO_3$)		5.9	4.9	7.3	4.8					0

TABLE 3-3 (continued)

MEDICINE CREEK

Parameter / Date of Sampling	21/5/77	27/7/77	6/8/77	13/9/77	18/10/77	27/4/78	7/7/78	BCH Lab 7/7/78	21/8/78	13/05/79	15/5/79	17/5/79	19/5/79	23/5/79	25/5/79	27/5/79	29/5/79	31/5/79	2/6/79	4/6/79	6/6/79
PHYSICAL DATA (mg/L)																					
pH (units)	8.4	8.5	8.5	8.5	8.5	7.8	7.9	8.0	8.2	8.5	8.6	8.6	8.6	8.6	8.5	8.6	8.7	8.7	8.2	8.6	8.5
Specific Conductance (µmhos/cm @ 25° C)	550	470	500	482	473	338	220	200	500	479	480	539	560	586	602	606	604	603	556	596	603
True Color (Pt-Co Units)	10																				
Turbidity (NTU)	0.30					18	32		1.1												
Temperature (°C)	7																				
Total residue	361							212											389	400	396
Filtrable residue	359	304	322	318	297	218	158	164	337	308	319	355	369	385	399	404	407	408	368	396	389
Non-filtrable residue	2					109	72	48.1	<1	16	15	11	10	10	5	4	2	2	21	4	7
Fixed total residue	261																				
Fixed filtrable residue	260																				
Fixed non-filtrable residue	1																				
Settleable Matter (by weight) mg/L						79	44	103.1													

TABLE 3-3 (continued)

MEDICINE CREEK

Parameter / Date of Sampling — PHYSICAL DATA (mg/L)	8/6/79	10/6/79	11/6/79	12/6/79	14/6/79	16/6/79	18/6/79														
pH (units)	8.5	8.4	8.3	8.5	8.6	8.6	8.6														
Specific Conductance (µmhos/cm @ 25° C)	618	616	491	620	613	616	621														
True Color (Pt-Co Units)																					
Turbidity (NTU)																					
Temperature (°C)																					
Total residue	416	407	316	420	408	423	424														
Filtrable residue	411	401	312	415	405	419	419														
Non-filtrable residue	5	6	4	5	3	4	5														
Fixed total residue																					
Fixed filtrable residue																					
Fixed non-filtrable residue																					
Settleable Matter (by weight) mg/L			<1																		

TABLE 3-4 - SURFACE WATER QUALITY ANALYSES - AMBUSTEN CREEK

(mg/L) Parameter Dissolved (D), Total (T) - CATIONS / Date of Sampling	11 / 06 / 79		AMBUSTEN CREEK																		
	D	T																			
Aluminum (Al)																					
Arsenic (As)																					
Cadmium (Cd)																					
Calcium (Ca)	66																				
Chromium (Cr)	<0.01																				
Copper (Cu)																					
Iron (Fe)	0.03																				
Lead (Pb)																					
Lithium (Li)																					
Magnesium (Mg)	23																				
Mercury (Hg)(ug/l)																					
Molybdenum (Mo)																					
Nickel (Ni)																					
Potassium (K)																					
Selenium (Se)																					
Sodium (Na)	7.3																				
Strontium (Sr)																					
Vanadium (V)																					
Zinc (Zn)	<0.005																				
Silica (SiO_2) Dissolved Total	11																				
Silica Dissolved Molybdate Reactive	11																				

TABLE 3-4 (continued)

AMBUSTEN CREEK

Parameter (mg/L) Diss. (D), Total (T) ANIONS, ORGANIC, CALCULATED VALUES \ Date of Sampling	11 / 06 / 79 D	11 / 06 / 79 T
Boron (B)		
Chloride (Cl)	0.7	
Fluoride (F)		
Sulfate (SO_4)	25	
Total-Kjeldahl-Nitrogen (N)		
Nitrate-Nitrogen (NO_3 -N)		
Nitrite-Nitrogen (NO_2 -N)		
Total-Orthophosphate-Phosphorus (P)		
Dissolved-Total PO_4 Phosphorus (P)		
COD		
TOC		5.9
Phenol		
Total Hardness ($CaCO_3$)	260	
Total Alkalinity ($CaCO_3$)		255
BOD_5		
D.O.		
% Saturation		
Phenolphthalein Alkalinity	8.7	

TABLE 3-4 (continued)

AMBUSTEN CREEK

Date of Sampling / Parameter PHYSICAL DATA (mg/L)	11/6/79																				
pH (units)	8.6																				
Specific Conductance (µmhos/cm @ 25° C)	490																				
True Color (Pt-Co Units)																					
Turbidity (NTU)																					
Temperature (°C)																					
Total residue																					
Filtrable residue	295																				
Non-filtrable residue	<1																				
Fixed total residue																					
Fixed filtrable residue																					
Fixed non-filtrable residue																					

TABLE 3-5 - SURFACE WATER QUALITY ANALYSES - HOUTH CREEK

HOUTH CREEK

(mg/L) Parameter Dissolved (D), Total (T) – CATIONS / Date of Sampling	12/ 6 / 79 D	12/ 6 / 79 T
Aluminum (Al)	0.020	
Arsenic (As)		<0.005
Cadmium (Cd)		<0.005
Calcium (Ca)	36	
Chromium (Cr)	<0.01	
Copper (Cu)	<0.005	
Iron (Fe)	0.15	
Lead (Pb)	<0.01	
Lithium (Li)	<0.001	
Magnesium (Mg)	4.6	
Mercury (Hg)(ug/l)	<0.25	<0.30
Molybdenum (Mo)	0.002	
Nickel (Ni)	<0.01	
Potassium (K)	2.1	
Selenium (Se)	<0.003	
Sodium (Na)	6.6	
Strontium (Sr)	0.10	
Vanadium (V)	0.005	
Zinc (Zn)	<0.005	
Manganese (Mn)	<0.01	

TABLE 3-5 (continued)

Parameter / Date of Sampling	MOUTH CREEK																				
PHYSICAL DATA (mg/L)	12/6/79																				
pH (units)	8.2																				
Specific Conductance (µmhos/cm @ 25° C)	222																				
True Color (Pt-Co Units)																					
Turbidity (NTU)																					
Temperature (°C)																					
Total residue																					
Filtrable residue	153																				
Non-filtrable residue	10																				
Fixed total residue																					
Fixed filtrable residue																					
Fixed non-filtrable residue																					

TABLE 3-5 (continued)

MOUTH CREEK

(mg/L) Date of Sampling / Parameter Diss. (D), Total (T) ANIONS, ORGANIC, CALCULATED VALUES	12/ 06 / 79																			
	D	T																		
Boron (B)	<0.1																			
Chloride (Cl)	0.4																			
Fluoride (F)	0.081																			
Sulfate (SO_4)	4																			
Total-Kjeldahl-Nitrogen (N)																				
Nitrate-Nitrogen (NO_3 -N)	0.04																			
Nitrite-Nitrogen (NO_2 -N)	<0.005																			
Total-Orthophosphate-Phosphorus (P)																				
Dissolved-Total PO_4 Phosphorus (P)	0.026																			
COD																				
TOC	8																			
Phenol																				
Total Hardness($CaCO_3$)	109																			
Total Alkalinity($CaCO_3$)	115																			
BOD_5																				
D.O.																				
% Saturation																				

and from Hat Creek at the junction with Highway 12 near the site office. Half litre water samples were collected every second day, and then stored in a refrigerator until shipped to Beak Consultants Limited for analyses.

The results are shown in Table 3-6 and Figure 3-1. The suspended solids (non-filtrable residue) concentrations during the freshet were lower than last year likely due to the lower freshet flow which was due to the lower snowpack. On average, the levels of suspended solids at the Highway 12 junction were about two times greater than the levels in Hat Creek at the junction with Anderson Creek.

On the evening of 25 August 1979, 20.6 mm of rain fell in several hours. This intense rainfall caused relatively rapid runoff over sparsely vegetated areas and downhill roads near Trench A. The ground did not have time to absorb the volume of rain. Runoff was collected in the earthfill dam, built below the crushed coal piles specifically for this purpose. A 3-litre sample of this runoff was collected and sent to Beak Consultants Limited for analyses. The results of the analyses are presented in Table 3-7. These results reflect the quality of surface runoff from disturbed mining areas that may occur during periods of heavy precipitation.

3.3 Hat Creek Temperature Monitoring

Water temperatures in Hat Creek and Bonaparte River were monitored during the summer of 1979, from 2 June to 10 September. This was a continuation of a programme

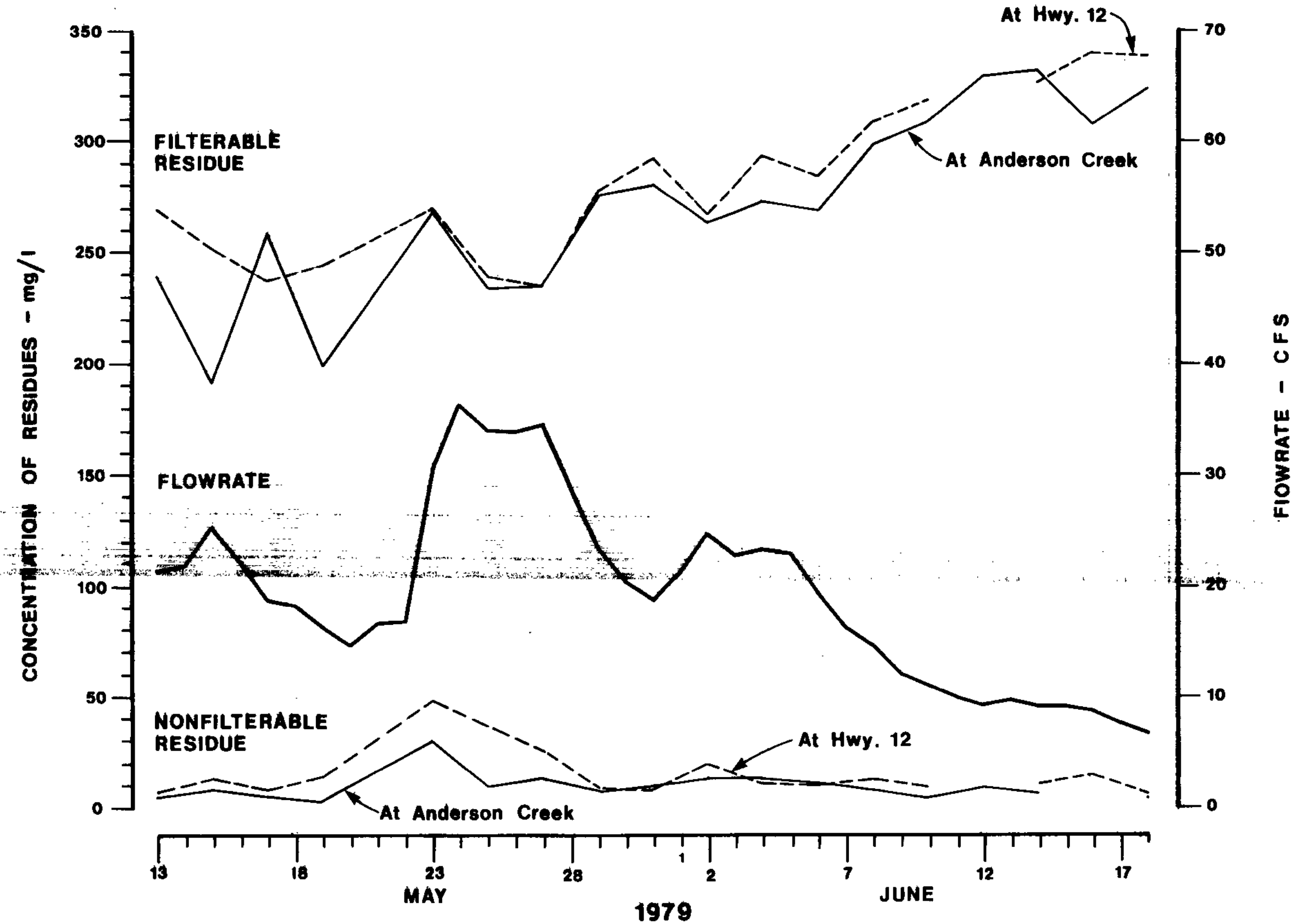


FIGURE 3-1 FILTERABLE AND NONFILTERABLE RESIDUES AND FLOWRATE

TABLE 3-6 - SURFACE WATER QUALITY ANALYSES - HAT CREEK AT ANDERSON CREEK AND HIGHWAY 12

HAT CREEK AT ANDERSON CREEK AND HIGHWAY 12

Parameter / Date of Sampling	13/05/79		15/05/79		17/05/79		19/05/79		23/05/79		25/05/79		27/05/79		29/05/79		31/05/79		2/06/79	
CHART #1	AC	Hwy 12	AC	Hwy 12	AC	Hwy 12	AC	Hwy 12	AC	Hwy 12	AC	Hwy	AC	Hwy 12	AC	Hwy 12	AC	Hwy 12	AC	Hwy 12
Conductivity μmho/cm	349	416	286	383	363	366	289	384	395	420	341	356	324	361	398	426	411	450	372	419
Filtrable Residue mg/l	239	268	191	251	259	237	199	244	268	269	234	239	235	235	275	277	280	292	264	287
Nonfiltrable Residue mg/l	5	7	9	14	6	9	4	15	32	48	10	37	14	26	8	10	10	9	14	20
pH	8.4	8.4	8.4	8.4	8.4	8.4	8.5	8.4	8.4	8.4	8.3	8.3	8.4	8.4	8.4	8.4	8.5	8.5	8.4	8.4
Nonfiltrable Residue Ratio	1.4		1.6		1.5		3.8		1.5		3.7		1.9		1.3		0.9		1.4	

Parameter / Date of Sampling	4/06/79		6/06/79		8/06/79		10/06/79		12/06/79		14/06/79		16/06/79		18/06/79					
CHART #2	AC	Hwy 12	AC	Hwy 12	AC	Hwy 12	AC	Hwy 12	AC	Hwy 12	AC	Hwy 12	AC	Hwy 12	AC	Hwy 12				
Conductivity μmho/cm	382	406	387	421	413	442	447	468	474	248	475	479	441	475	477	500				
Filtrable Residue mg/l	273	293	269	284	298	308	309	318	329	166	331	326	307	339	324	338				
Nonfiltrable Residue mg/l	14	12	12	11	9	13	5	10	10	63	7	11	*	15	5	7				
pH	8.4	8.4	8.5	8.4	8.4	8.4	8.4	8.4	8.4	8.3	8.3	8.3	8.3	8.3	8.5	8.3				
Nonfiltrable Residue Ratio	0.9		0.9		1.4		2.0		6.3		1.6		N.D.		1.4					

TABLE 3-7 - SURFACE RUNOFF QUALITY AT CRUSHER SITE DAM

Crusher Site Dam - Rain Runoff

Date of Sampling / (mg/L) Parameter Dissolved (D), Total (T) - CATIONS	29 / 8 / 79 Diss	Total
Aluminum (Al)	<0.02	
Arsenic (As)		<0.001
Cadmium (Cd)	<0.005	
Calcium (Ca)	100	
Chromium (Cr)	<0.01	
Copper (Cu)	0.005	
Iron (Fe)	0.07	
Lead (Pb)	<0.01	
Lithium (Li)	0.02	
Magnesium (Mg)	34	
Mercury (Hg)(ug/l)		<0.25
Molybdenum (Mo)	0.042	
Nickel (Ni)	<0.01	
Potassium (K)	9	
Selenium (Se)	<0.003	
Sodium (Na)	20	
Strontium (Sr)	0.4	
Vanadium (V)	0.009	
Zinc (Zn)	0.013	
Beryllium	<0.0003	
Uranium	0.00006	
Manganese	0.11	
Thorium	<0.10	

TABLE 3-7 (continued)

Crusher Site Dam - Rain Runoff

(mg/l.) Parameter Diss. (D), Total (T) ANIONS, ORGANIC, CALCULATED VALUES / Date of Sampling	29 / 8 / 79																				
	Diss	Total																			
Boron (B)	0.2																				
Chloride (Cl)	1.2																				
Fluoride (F)	0.127																				
Sulfate (SO_4)	350																				
Total-Kjeldahl-Nitrogen (N)																					
Nitrate-Nitrogen (NO_3 -N)	3.5																				
Nitrite-Nitrogen (NO_2 -N)	0.23																				
Total-Orthophosphate-Phosphorus (P)																					
Dissolved-Total PO_4 Phosphorus (P)	0.030																				
COD																					
TOC	26																				
Phenol																					
Total Hardness ($CaCO_3$)	390																				
Total Alkalinity ($CaCO_3$)		70																			
BOD_5																					
D.O.																					
% Saturation																					

TABLE 3-7 (continued)

Crusher Site Dam - Rain Runoff

Date of Sampling / Parameter																					
PHYSICAL DATA (mg/L)	29/8/79																				
pH (units)	7.5																				
Specific Conductance (µmhos/cm @ 25° C)	846																				
True Color (Pt-Co Units)																					
Turbidity (NTU)	5.2																				
Temperature (°C)																					
Total residue																					
Filtrable residue	738																				
Non-filtrable residue	21																				
Fixed total residue																					
Fixed filtrable residue																					
Fixed non-filtrable residue																					

conducted from 20 August to 5 October 1978.

There ~~was~~ were three stations in Hat Creek (1) at Anderson Creek; (2) at Highway No. 12 junction; and (3) at the Bonaparte River. These were located in shaded or semi-shaded areas. Station (4) was in the Bonaparte River just below Hat Creek in a semi-shaded area and station (5) was in the Bonaparte River just above Hat Creek in an unshaded area. The location of these five stations is shown in Figure 3-2. Peabody "J" thermograph recorders were installed at the same five locations as in 1978 except for positions (3) and (4). Station (3) was moved 40 m upstream from the original site while station (4) was relocated 150 m downstream, both to more suitable positions. The five thermographs were calibrated regularly. The results of six calibrations are shown in Table 3-8.

Table 3-8 - Calibration of Peabody Thermographs

Thermograph Station No.	31 May	2 June	10 Sept	11 Sept	11 Sept	18 Sept
1	23.2°C	18.2°C	19.5°C	21.1°C	21.3°C	24.9°C
2	(14.2)	(8.2)	18.7	20.7	20.3	23.5
3	23.7	18.3	19.1	20.1	20.3	24.3
4	23.0	17.8	18.7	20.3	20.4	24.1
5	24.5	18.0	18.8	20.8	20.8	24.3
Mercury Thermometer	-	-	-	20.4	21.6	24.7

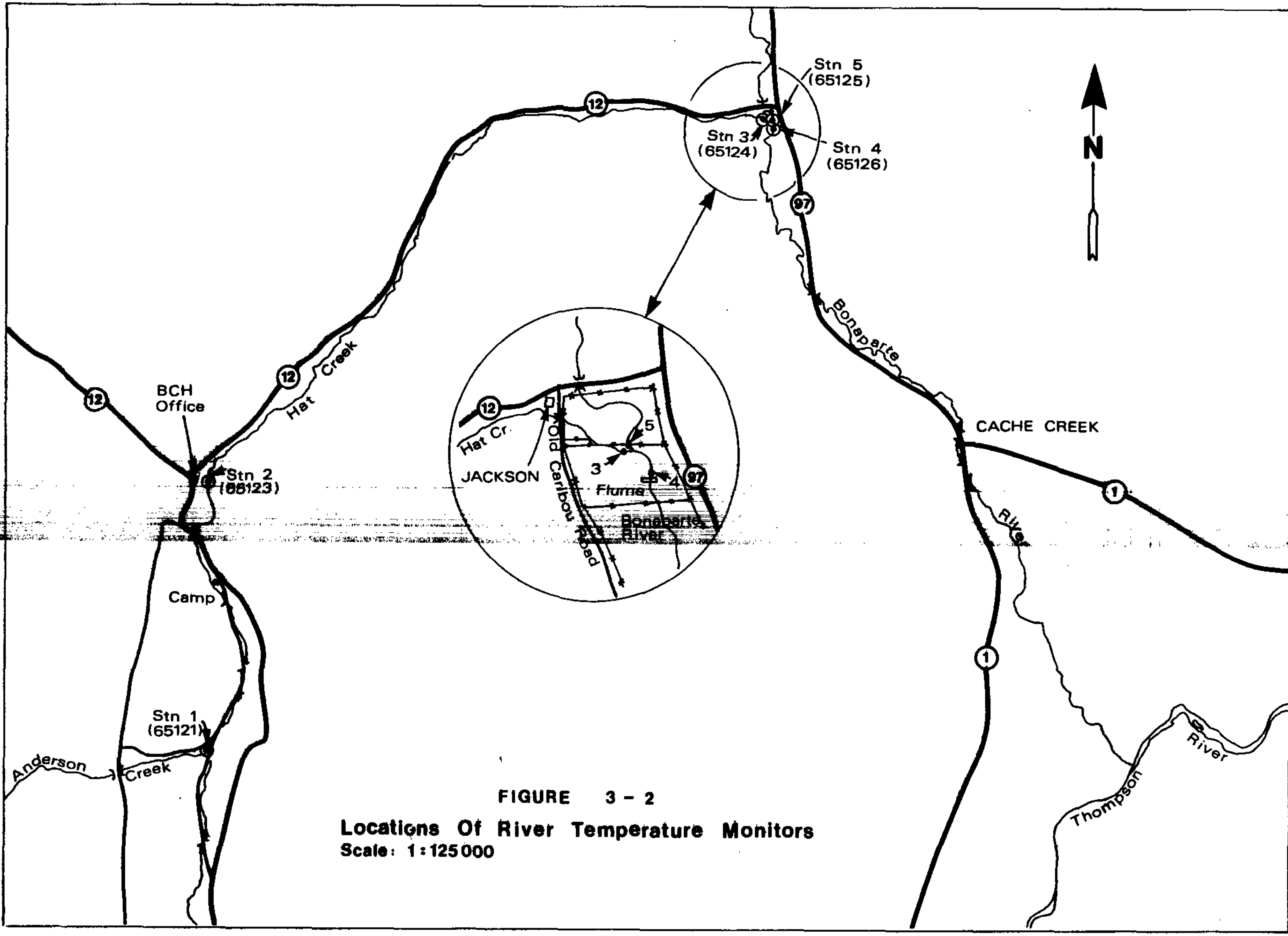


FIGURE 3 - 2

Locations Of River Temperature Monitors

Scale: 1:125000

The thermograph at station (2) was not installed until 19 July because of calibration problems. Maximum-minimum thermometers were not used in this programme during 1979.

An iron stake was driven into the streambed. The "J" was then rigidly tied on at the bottom. Two safety lines were secured to different points on the bank. Four of the "J" recorders were resealed using silicone grease and then secured onto the stake in a loose, reclined position. Subsequently, one thermograph recorder was opened and tampered with by vandals.

Because of drops in the water level downstream from an irrigation pumphouse, the recorder at site (3) had to be moved twice to deeper water. The first move was required when the "J" was no longer submersed. The second move was needed when the creek dried up completely, from the mouth to 160 m upstream. The second move was to the bottom of a pool where the creek terminated, about 12 m above the original site. After the irrigation pumping was discontinued, normal water levels were reestablished.

The maximum and minimum readings from the thermographs are recorded in Table 3-9. Comparisons of the temperatures at sites (3), (4) and (5) indicate that Hat Creek has little effect on the temperature of the Bonaparte River. The springs below Houth Meadows may have a moderating effect on the Hat Creek water temperatures as determined from comparing minimum temperatures at sites (1) and (2). During the summer months, the Hat Creek temperature increased approximately 4°C from Anderson Creek to the Bonaparte River, a distance of about 32 km. There were periods in late June, mid July, and mid August when temperatures exceeded 20°C. The maximum temperature in Hat Creek was 24°C at

TABLE 3-9 - MAXIMUM AND MINIMUM RIVER TEMPERATURES

DATE	HAT CREEK						BONAPARTE RIVER			
1979	STATION (1)		STATION (2)		STATION (3)		STATION (4)		STATION (5)	
JUNE 2	-	12.8	-	-	-	17.3	-	16.8	-	16.9
3	8.2	11.4	-	-	12.0	15.3	12.3	15.3	12.5	15.5
4	9.5	11.1	-	-	13.0	14.8	12.8	14.9	13.0	15.0
5	8.6	11.2	-	-	11.4	12.7	12.2	13.7	12.2	14.0
6	7.9	9.4	-	-	10.3	11.9	11.0	12.5	11.0	12.6
7	6.9	10.4	-	-	8.4	13.3	10.0	14.0	10.1	14.1
8	7.7	11.1	-	-	9.4	14.1	10.6	14.1	11.0	14.4
9	8.5	13.1	-	-	10.8	16.3	11.8	16.8	12.0	17.0
10	9.0	12.2	-	-	11.6	16.0	12.8	16.0	13.0	16.0
11	10.0	13.0	-	-	12.9	16.3	12.8	16.0	13.0	16.2
12	9.2	13.1	-	-	11.0	16.0	12.3	15.9	12.7	16.1
13	9.6	12.0	-	-	11.0	14.5	12.0	14.6	12.6	15.0
14	8.8	10.8	-	-	10.9	14.8	11.6	14.6	11.8	15.0
15	7.8	10.0	-	-	9.7	15.3	11.0	14.0	11.3	14.3
16	8.3	9.7	-	-	11.0	13.0	11.7	13.5	12.0	14.0
17	8.8	12.6	-	-	11.0	17.8	12.0	17.0	12.3	17.3
18	9.4	12.3	-	-	12.4	17.5	13.2	17.1	13.7	17.7
19	10.0	10.6	-	-	14.0	15.0	13.7	14.8	14.0	15.2
20	8.9	10.4	-	-	11.8	15.2	12.8	15.1	13.0	15.5
21	8.1	11.0	-	-	11.1	15.8	12.6	16.0	13.0	16.2
22	8.2	11.4	-	-	11.2	15.2	12.3	15.2	12.8	15.7
23	8.2	12.0	-	-	10.7	16.7	11.9	15.9	12.3	16.1
24	8.3	12.5	-	-	11.7	17.7	12.0	16.7	12.3	17.0
25	9.4	13.4	-	-	11.4	18.7	12.1	17.3	12.7	17.8
26	9.7	14.7	-	-	12.4	20.1	13.0	18.5	13.3	19.0
27	10.8	14.8	-	-	13.9	21.0	14.4	19.6	14.8	20.0
28	10.8	15.0	-	-	13.7	20.2	14.7	19.0	14.9	19.4
29	10.7	13.8	-	-	14.0	19.0	14.7	18.2	14.9	18.7
30	10.3	11.1	-	-	13.6	14.7	14.0	14.8	14.4	14.9
1	8.5	9.1	-	-	11.3	13.8	12.3	14.0	12.7	14.2
2	7.7	9.0	-	-	9.7	12.0	11.0	12.7	11.4	13.0
3	7.8	11.8	-	-	9.7	16.0	11.0	15.6	11.2	15.8
4	9.7	10.7	-	-	12.3	15.0	13.1	14.9	13.2	15.1
5	9.4	12.8	-	-	12.2	16.0	13.3	15.9	13.5	16.0
6	10.4	14.0	-	-	13.1	19.2	14.0	18.6	14.2	18.7
7	12.5	13.2	-	-	14.7	17.8	15.2	17.5	15.4	18.0
8	10.8	13.1	-	-	13.7	17.8	14.3	17.0	14.8	17.3
9	11.1	13.0	-	-	13.7	18.3	14.0	17.1	14.2	17.4
10	12.0	13.2	-	-	14.9	17.4	14.8	17.0	15.0	17.3
11	11.1	12.1	-	-	13.5	16.5	14.0	16.7	14.3	17.0
12	-	-	-	-	13.1	16.0	13.7	16.0	14.0	16.0
13	-	-	-	-	12.8	17.0	13.4	16.5	13.8	16.8
14	-	-	-	-	13.9	18.7	15.0	17.4	14.4	18.6
15	-	-	-	-	13.0	20.2	14.5	18.1	13.9	19.3
16	-	-	-	-	14.2	21.0	15.5	18.8	15.0	19.9
17	-	-	-	-	15.6	22.7	16.5	20.1	15.8	21.0
18	-	16.3	-	-	16.0	23.7	17.2	-	16.6	-
19	13.0	17.1	-	-	17.2	24.0	-	-	-	22.3
20	13.7	17.8	12.9	19.3	17.7	22.7	-	-	18.3	22.2
21	-	-	13.1	18.0	19.3	21.6	-	-	18.8	21.0

DATE	HAT CREEK						BONAPARTE RIVER			
1979	STATION (1)		STATION (2)		STATION (3)		STATION (4)		STATION (5)	
JULY 22	-	-	11.4	17.1	16.3	21.1	-	-	17.5	20.3
23	-	-	11.5	17.7	16.2	20.8	-	-	16.5	19.7
24	-	-	11.0	16.0	15.5	19.7	-	-	15.9	18.8
25	-	-	9.9	16.4	16.2	19.5	-	-	15.3	19.5
26	-	-	9.6	16.1	-	21.0	-	-	15.7	20.5
27	-	-	9.8	17.5	-	-	-	-	17.5	20.0
28	-	-	10.3	16.2	-	-	-	-	-	-
29	-	15.1	9.6	13.5	-	19.4	-	-	-	18.7
30	12.3	16.4	9.3	16.7	15.5	21.0	-	-	16.2	20.5
31	13.2	16.1	9.7	16.9	16.7	21.6	-	-	17.2	21.1
AUG 1	12.7	16.3	9.0	17.0	15.8	20.0	-	-	16.5	20.3
2	12.8	15.6	9.7	15.2	15.7	20.2	-	-	16.5	19.4
3	12.8	13.8	9.8	12.9	15.7	19.0	-	-	16.2	18.8
4	11.0	14.0	9.0	14.5	14.0	18.8	-	-	14.9	18.2
5	12.0	14.5	10.0	15.5	-	-	-	-	16.0	19.8
6	11.0	13.4	8.8	14.4	-	17.5	-	18.2	15.0	-
7	10.0	13.5	8.0	14.9	14.0	18.8	14.4	18.6	-	-
8	10.6	14.2	8.8	15.0	9.0	18.8	14.7	19.0	-	-
9	11.1	15.0	8.8	15.2	13.7	18.1	14.7	19.3	-	-
10	11.8	15.5	8.6	16.0	14.7	19.2	15.2	19.4	-	-
11	12.9	15.5	9.3	15.9	16.0	20.8	16.1	20.0	-	-
12	11.8	15.2	8.4	16.1	-	19.9	15.0	20.1	-	20.4
13	12.7	15.4	8.8	15.4	15.9	21.2	15.9	20.1	16.2	20.6
14	13.0	14.8	9.7	13.6	16.4	18.1	16.0	17.5	16.6	17.8
15	13.5	14.5	10.2	12.3	15.1	17.1	15.5	16.4	16.0	16.8
16	13.0	14.7	10.0	14.5	15.7	20.0	14.8	18.8	15.4	19.1
17	12.7	14.2	9.3	12.6	15.3	17.7	15.5	16.3	16.1	17.7
18	11.8	13.5	8.4	12.4	14.6	17.2	14.9	17.0	15.5	17.3
19	11.7	14.1	8.7	14.7	14.7	19.0	14.8	18.7	15.2	19.1
20	12.7	14.7	9.5	13.3	15.0	19.0	15.7	18.2	16.0	18.7
21	12.7	15.3	9.1	16.1	15.5	19.2	15.4	18.0	-	-
22	13.5	16.0	9.7	15.2	16.2	20.7	16.2	19.9	-	-
23	13.2	15.7	9.7	14.2	16.3	19.7	16.5	19.0	-	-
24	13.6	14.6	10.1	13.8	16.3	19.0	16.5	18.6	-	-
25	11.8	14.0	8.2	14.0	14.3	18.8	14.9	18.7	-	-
26	11.8	14.8	9.7	15.2	14.7	19.7	14.9	19.5	-	-
27	12.7	14.5	10.8	14.6	14.7	18.6	15.0	18.7	-	-
28	12.7	15.7	10.2	15.8	14.7	19.7	14.8	19.0	-	-
29	12.5	15.6	9.5	15.9	14.2	19.4	15.0	19.0	-	-
30	12.0	15.0	9.0	15.0	13.7	18.4	14.7	18.1	-	-
31	12.6	13.7	9.8	11.7	-	-	15.7	17.0	-	-
SEPT 1	12.0	13.8	9.2	12.8	-	-	14.6	17.0	-	-
2	12.0	13.7	9.0	13.7	-	-	14.4	17.0	-	-
3	11.0	12.4	8.0	12.0	-	-	14.4	15.8	-	-
4	10.0	11.6	7.7	10.3	-	-	12.5	14.5	-	-
5	10.0	12.2	8.0	12.1	-	-	12.2	15.0	12.8	15.2
6	9.7	11.2	7.2	11.0	-	-	11.6	13.8	12.2	14.2
7	9.2	11.2	7.3	11.8	-	-	11.2	14.2	11.9	14.8
8	10.5	12.2	9.0	12.5	-	-	13.0	15.0	-	-
9	10.0	-	8.7	12.4	-	-	12.4	14.6	-	-

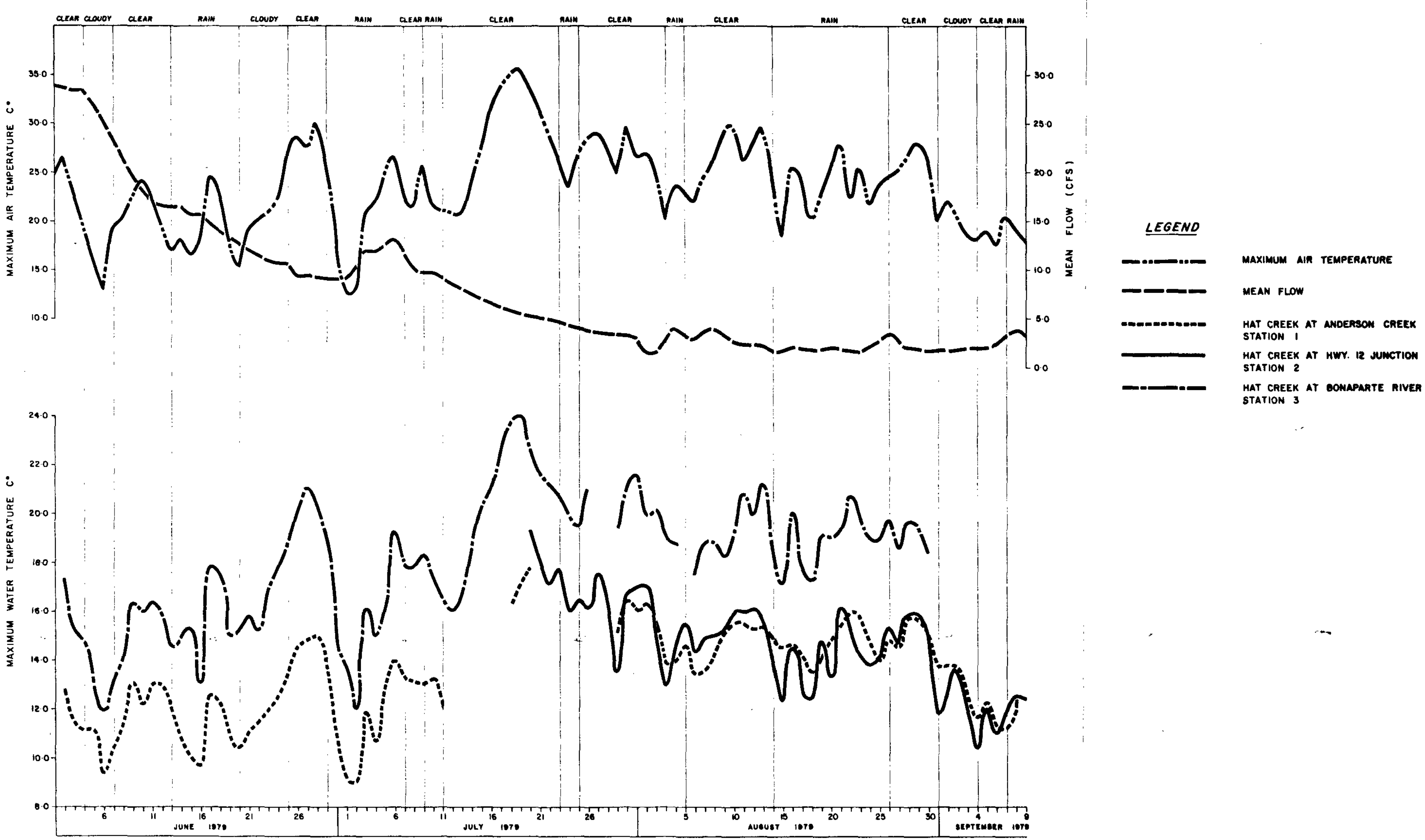
site (3) on 19 July. The minimum temperatures usually occurred at 7:00 a.m. and the maximum temperatures at 6:00p.m. Because of the shallowness and turbulence of the creek, depth was not considered as a factor in the analyses. As shown in Figure 3-3, the water temperatures are more closely correlated to the weather than to flow rate.

Several observations were noted during the programme. An extensive filamentous algae bloom clogged the creek at site (2) for over a month in July and August. At all of the sites, large numbers of caddis fly larvae, parasitic worms and micro-organisms attached themselves to the "J" thermographs. During the lowest water level period, several deep pools had large populations of two species of fish. Two dead fish were found during the warm weather, but the cause of death was not determined.

3.4 Hat Creek Flowrate

During the period 15 to 25 August 1979, a segment of Hat Creek dried up completely. This segment was from just south of Trench B to about one km downstream where the creek was fed by springs in the fields below Houth Meadows. About 1.5 km upstream of the Trench B area there was a small flow in the creek. The very low snowpack, the dry summer and extensive irrigation contributed to the lack of water in Hat Creek. The flow in segments of Hat Creek has been known to dry up completely in the past. These occurrences are probably due to excessive extraction of water from the creek for irrigation purposes during the dry summer months.

When a segment of Hat Creek dried up in 1979, B.C. Hydro was accused of causing the lack of water in Hat Creek. A professional groundwater hydrologist visited the area and confirmed B.C.



HAT CREEK PROJECT
1979 ENVIRONMENTAL FIELD PROGRAM

FIGURE 3-3

STREAM TEMPERATURE MONITORING

Hydro activities in the area had no appreciable affect on the flow in Hat Creek.

It was also suggested that the Trench B excavation near the creek might be reducing the flow in Hat Creek. Gauging stakes were installed in Trench B and in Hat Creek adjacent to Trench B to monitor water levels in Trench B and in Hat Creek. Water level measurements in the fall of 1979 showed that the levels were similar. It is planned to continue the monitoring of water levels at these two locations during 1980.

3.5 Groundwater

In June 1979, samples of water were collected from wells established in 1977 for groundwater monitoring. Samples from groundwater wells #2 and #3 near Trench B were collected and preserved by Acres and sent to Beak for analyses.

The results of the groundwater quality monitoring programme are shwon in Table 3-10 and 3-11. The groundwater quality for well #2 in 1979 showed no significant variation from the previous years. The 1979 results for well #3 show noticeable decreases in aluminium, calcium, and iron compared to 1978 and the concentration of non-filtrable residue increased greatly.

3.6 Waste Coal Leachates

In 1978, leachate samples were collected from specially prepared sites at the base of the coaly waste and low grade piles for study. Three samples were taken in April, June and August and

TABLE 3-10 - GROUND WATER QUALITY - WELL #2

(mg/L) Parameter Dissolved (D), Total (T) - CATIONS / Date of Sampling	7/6/77	21/6/77	6/7/77	20/7/77	20/10/77		30/11/77		8/6/78		22/8/78		GROUNDWATER WELL NO. 2 12/06/79	
					Diss.	Total	Diss.	Total	Diss.	Total	Diss.	Total	Diss.	Total
Aluminum (Al)	*	*	0.010	0.030	<0.010	0.68	0.010	0.40	0.013	0.28	0.009	0.30	0.005	
Arsenic (As)	*	*	*	*	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005		<0.005
Cadmium (Cd)														
Calcium (Ca)	64	75	65	66	79	79	59		57	57	59	59	66	
Chromium (Cr)	*	*	*	*	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.01	
Copper (Cu)	*	*	*	*	<0.005	<0.005	<0.005	<0.005	0.012	0.019	<0.005	0.006	0.006	
Iron (Fe)	0.034	0.024	0.035	0.13	0.026	0.44	0.011	0.42	0.015	0.28	0.015	0.31	<0.01	
Lead (Pb)														
Lithium (Li)	0.003	0.004	0.005	0.004	0.004	0.004	0.003	0.003	0.002	0.002	0.003	0.003	0.004	
Magnesium (Mg)	15	15	16	16	17	17	13		14	14	14	15	17	
Mercury (Hg)(ug/l)	*	*	*	*	<0.25	<0.25	<0.25	<0.25	0.27	0.32	0.37	0.37	0.26	
Molybdenum (Mo)														
Nickel (Ni)									<0.010	<0.010			<0.01	
Potassium (K)														
Selenium (Se)	0.006	0.005	*	0.004	0.004		0.003		<0.003	<0.003	<0.003	<0.003	<0.003	
Sodium (Na)	18	18	18	18	18	19	20		16	17	33	33	29	
Strontium (Sr)	0.20	0.21	0.28	0.23	0.24	0.24	0.19	0.21	0.31	0.32	0.24	0.27	0.27	
Vanadium (V)	*	*	*	0.001	0.003	0.003	<0.003	0.003	0.002	0.004	0.006	0.006	0.004	
Zinc (Zn)	*	0.014	0.008	0.041	<0.005	0.011	0.032	0.007	0.005	0.010	0.011	0.029	<0.005	
Manganese (Mn)					0.085	0.092	0.012	0.026					0.05	
* Denotes <MDC														

TABLE 3-10 (continued)

(mg/L) Parameter Diss. (D), Total (T) ANIONS, ORGANIC, CALCULATED VALUES / Date of Sampling	7/6/77	21/6/77	6/7/77	20/7/77	20/10/77		30/11/77		8/6/78		22/8/78		GROUNDWATER WELL NO. 2 14/06/79	
					Diss.	Total	Diss.	Total	Diss.	Total	Diss.	Total	Diss.	Total
Boron (B)	*	*	*	*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.10	<0.10	<0.1	
Chloride (Cl)	1.7	1.4	1.3	1.3		1.0		0.88		1.4		1.4	1.9	
Fluoride (F)	0.104	0.128	0.135	0.146		0.140		0.107		0.14		0.18	0.152	
Sulfate (SO_4)	38	45	54	48		120		61		57		41	64	
Total-Kjeldahl-Nitrogen (N)														
Nitrate-Nitrogen (NO_3 -N)													0.17	
Nitrite-Nitrogen (NO_2 -N)													<0.005	
Total-Orthophosphate-Phosphorus (P)														
Dissolved-Total PO_4 Phosphorus (P)	0.032	0.033	0.043	0.009	0.12		0.015		0.017		0.020		0.028	
COD														
TOC	27	32	24	50		12		22		10		<2		4
Phenol														
Total Hardness($CaCO_3$)	222	249	228	231		267		201		200		205	235	
Total Alkalinity($CaCO_3$)	229	232	231	241		200		179		208		232		253
BOD_5														
D.O.														
% Saturation														
* Denotes <MDC														

TABLE 3-10 (continued)

Parameter / Date of Sampling — PHYSICAL DATA (mg/L)	7/6/77	21/6/77	6/7/77	20/6/77	20/10/77	30/11/77	8/6/78	22/8/78	14/06/79	GROUNDWATER WELL NO. 2
pH (units)	7.6	7.4	7.4	7.6	7.4	7.7	7.6		7.7	
Specific Conductance (μmhos/cm @ 25° C)	510	520	531	540	582	460	470	514	578	
True Color (Pt-Co Units)										
Turbidity (NTU)							1.8	2.5		
Temperature (°C)										
Total residue	354	370	409	387	404	318	317	358	374	
Filtrable residue	330	346	340	349	389	304	310	350	368	
Non-filtrable residue	24	24	69	38	15	14	7	8	6	
Fixed total residue										
Fixed filtrable residue										
Fixed non-filtrable residue										
* Denotes <MDC										

TABLE 3-11 - GROUND WATER QUALITY - WELL #3

(mg/L) Parameter Dissolved (D), Total (T) - CATIONS / Date of Sampling	7/6/77	21/6/77	6/7/77	20/7/77	4/8/77	30 / 11 / 77		8 / 6 / 78		22 / 8 / 78		12/6/79	
	GROUNDWATER WELL No. 3					D	T	D	T	D	T	D	T
Aluminum (Al)	*	*	*	0.057	*	0.17	1.1	0.32	16	0.027	40	0.009	
Arsenic (As)	*	*	*	*	*	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005		<0.005
Cadmium (Cd)												<0.005	
Calcium (Ca)	260	260	230	250	230	310		290	290	300	320	56	
Chromium (Cr)	*	*	*	*	*	<0.010	<0.010	<0.010	0.023	<0.010	<0.010	<0.01	
Copper (Cu)	0.007	*	*	*	*	0.006	0.014	0.024	0.087	0.020	0.095	<0.023	
Iron (Fe)	0.060	0.081	0.23	0.25	0.19	0.039	2.6	0.19	11	0.025	23	<0.01	
Lead (Pb)												<0.01	
Lithium (Li)	0.064	0.063	0.067	0.007	0.055	0.060	0.060	0.12	0.11	0.15	0.15	0.11	
Magnesium (Mg)	81	83	85	88	65	97		110	110	100	120	97	
Mercury (Hg) (µg/l)	*	*	*	*	0.63	<0.25	<0.25	0.45	0.57	0.36	0.59	0.26	0.49
Molybdenum (Mo)												0.003	
Nickel (Ni)								0.010	0.034			0.01	
Potassium (K)												18	
Selenium (Se)	*	*	*	*	*	<0.003		0.006	<0.003	<0.003	<0.003	<0.003	
Sodium (Na)	360	380	400	440	340	460		450	460	580	580	550	
Strontium (Sr)	0.72	0.70	2.1	0.99	1.8	1.1	1.1	1.5	0.98	1.9	1.9	2.4	
Vanadium (V)	*	*	0.008	*	0.003	0.005	0.006	0.004	0.029	<0.01	0.070	0.001	
Zinc (Zn)	0.024	0.016	0.012	0.13†	0.10	0.18	0.018	0.031	0.063	0.017	0.088	0.016	
Manganese (Mn)						0.40	0.40					<0.01	

* Denotes MDC

† Contamination Suspected

TABLE 3-11 (continued)

Parameter (mg/L) Dis. (D), Total (T) ANIONS, ORGANIC, CALCULATED VALUES / Date of Sampling	GROUNDWATER WELL No. 3												
	7/6/77	21/6/77	6/7/77	20/7/77	4/8/77	30 / 11 / 77		8 / 6 / 78		22 / 8 / 78		12/ 06 / 79	
						D	T	D	T	D	T	D	T
Boron (B)	0.2	0.2	0.1	0.2	0.2	0.2	0.2	0.66	0.87	0.69	0.81	0.3	
Chloride (Cl)	7.4	7.5	7.3	7.4	7.7		7.8		20		11	11	
Fluoride (F)	0.105	0.134	0.134	0.133	0.135		0.127		0.12		0.11	0.119	
Sulfate (SO_4)	1400	1300	1360	1280	1300		3800		1500		1800	1700	
Total-Kjeldahl-Nitrogen (N)													
Nitrate-Nitrogen (NO_3 -N)												1.5	
Nitrite-Nitrogen (NO_2 -N)												<0.005	
Total-Orthophosphate-Phosphorus (P)													
Dissolved-Total PO_4 Phosphorus (P)	0.038	0.035	0.046	0.034	0.048	0.024		0.018		0.013		0.035	
COD													
TOC	97	102	101	80	61		28		70		95		91
Phenol													
Total Hardness($CaCO_3$)	983	991	924	987	842		1173		1180		1161	1024	
Total Alkalinity($CaCO_3$)	464	506	538	572	586		458		562		646		277
BOD_5													
D.O.													
% Saturation													

TABLE 3-11 (continued)

Parameter \ Date of Sampling	GROUNDWATER WELL No. 3								
PHYSICAL DATA (mg/L)	7/6/77	21/6/77	6/7/77	20/7/77	4/8/77	30/11/77	8/6/78	22/8/78	12/6/79
pH (units)	7.8	7.3	7.2	7.3	7.3	7.8	7.8	7.3	7.9
Specific Conductance (μmhos/cm @ 25° C)	3000	3000	2970	3030	3030	3380	3600	3815	3730
True Color (Pt-Co Units)									
Turbidity (NTU)								560	
Temperature (°C)									
Total residue	2871	2877	2845	2851	2846	3246	3770	3364	4350
Filtrable residue	2710	2730	2700	2690	2740	3050	3280	3185	3150
Non-filtrable residue	161	147	132	161	106	196	490	179	1200
Fixed total residue									
Fixed filtrable residue									
Fixed non-filtrable residue									

then daily collections were made in September, October and November. From the onset of the spring thaw, 1 March, until 31 December 1979, the daily programme was continued to further investigate the characteristics of the leachate flow.

In Table 3-12 and Figure 3-4 the volumes of leachate, average ambient temperature, and daily precipitation are presented. Several samples were sent to Vancouver for detailed analyses. The results of these analyses are presented in Table 3-14.

The response to rainfall was slow, and at times non-existent, until August, September and October, when the volumes increased dramatically immediately after it rained. Decreases in the leachate volume from the coaly waste piles corresponded to drops in the temperature to below 0°C, whereas only slight increases occurred in the flow after rainfalls. From the day the frost broke until it set again, there was a relatively steady flow of leachate from the coaly waste pile. The reasons why the flow remained relatively constant are not known.

From 1 March to 31 December, approximately 1245 l of leachate came out of the coaly waste pile while 66 l came from the low grade pile. During this time, 129.5 mm of rain fell. The volume of leachate collected from the coaly waste pile was about 0.9% of the volume of rain which fell onto the pile. This figure disregards the snowfall. The volume of leachate from the smaller low grade coal pile was about 0.2% of the rainfall onto the pile.

TABLE 3-12

LEACHATE FROM COAL WASTE AND LOW GRADE COAL PILES

DATE	RAIN	COALY WASTE		LOW GRADE COAL	
MARCH 1979	mm	VOLUME ml	pH	VOLUME ml	pH
1	0	0		0	
2	0	0		0	
3	0	0		0	
4	0	Trace		Trace	
5	0	> ?		0	
6	1.0	> 200	3.85	10	
7	1.0	> ?		Trace	
8	0	250	4.40	100	4.20
9	0	10		0	
10	0	50		0	
11	0	Trace		Trace	
12	0	Trace		Trace	
13	0	Trace		Trace	
14	0	Trace		Trace	
15	0.2	0		0	
16	0	150	4.20	60	4.20
17	0	0		250	4.15
18	0	0		0	
19	0	0		0	
20	0	Trace		Trace	
21	0	150	5.20	120	4.75
22	0	Trace		0	
23	0	Trace		200	
24	0	Trace			
25	0	Trace			
26	0	Trace		} 9250	4.15
27	0	Trace		2200	4.10
28	0	Trace		750	4.15
29	0	0		0	
30	0	0		Trace	
31	0	0		0	
Total	2.2	> 810 > Overflow		12,940	

TABLE 3-12 (Cont'd)

LEACHATE FROM COAL WASTE AND LOW GRADE COAL PILES

DATE	RAIN	COALY WASTE		LOW GRADE COAL	
APRIL 1979	mm	VOLUME ml	pH	VOLUME ml	pH
1	0	0			
2	*	Trace			
3	0	0		150	4.10
4	0.8	0		2100	3.95
5	0	0		1200	4.00
6	0.6	0		1150	3.90
7	0.4	0		850	4.05
8	0	0		850	3.85
9	0.8	0		650	3.85
10	0.6	0		700	3.80
11	*	0			
12	0	0			
13	0	0			
14	0	0			
15	0	0			
16	2.2	0			
17	2.4	0			
18	0.8	0			
19	1.0	0		4400	-
20	0	0			
21	0	0		250	3.85
22	0	0		200	3.80
23	0	0		200	3.80
24	0	0		150	3.80
25	0	0		150	3.90
26	0	0		150	3.95
27	0	0		130	3.90
28	0	0			
29	0	0			
30	Trace	0		330	3.80
Total	9.6 *snow	Trace		13,610	

TABLE 3-12 (Cont'd)

LEACHATE FROM COAL WASTE AND LOW GRADE COAL PILES

DATE	RAIN	COALY WASTE		LOW GRADE COAL	
MAY 1979	mm	VOLUME ml	pH	VOLUME ml	pH
1	0	0		120	4.05
2	0				
3	1.0				
4	0.2				
5	5.0	150	4.05	340	3.95
6	0.4	Trace		80	3.95
7	0	Trace		50	3.90
8	2.2	0		50	3.90
9	0.6	0		50	3.90
10	0	0		50	3.95
11	0	0		50	3.95
12	0	0		30	3.90
13	0	Trace		30	3.90
14	0			20	3.90
15	0	60	3.80	10	
16	0				
17	0	770	3.90	10	
18	0	1500	3.80	Trace	
19	0	2350	3.75	Trace	
20	0	3760	3.70	0	
21	0	3560	3.75	0	
22	0			0	
23	0.4	8550	3.75	0	
24	0	3650	3.85	0	
25	0	4350	3.75	0	
26	0.4	4900	3.75	0	
27	0	4600	3.75	0	
28	1.0	4410	3.85	0	
29	0	4210	3.75	0	
30	0	4000	3.75	0	
31	Trace	3810	3.80	0	
Total	11.2	54,630		890	

TABLE 4-4 - PRECIPITATION AT HAT CREEK AS MEASURED AT I. LEHMAN RESIDENCE

MONTH (1979)	RAIN (mm)	SNOW (cm)
JANUARY	0	42.0
FEBRUARY	0	11.0
MARCH	2.2	3.5
APRIL	9.6	10.5
MAY	11.2	0
JUNE	9.4	0
JULY	16.0	0
AUGUST	42.8	0
SEPTEMBER	14.0	0
OCTOBER	17.8	0
NOVEMBER	0	2
DECEMBER	6.6	53.3
TOTAL:	129.6	122.3
TOTAL PRECIPITATION: 251.9 mm.		

TABLE 3-12 (Cont'd)

LEACHATE FROM COAL WASTE AND LOW GRADE COAL PILES

DATE	RAIN	COALY WASTE		LOW GRADE COAL	
JULY 1979	mm	VOLUME ml	pH	VOLUME ml	pH
1	8.1	4600	4.05	0	
2	3.3	4400	4.05	0	
3	0	3600	4.00	0	
4	1.2	5900	4.05	0	
5	1.6	3300	4.00	} 100	3.95
6	0	5510	4.05		
7	0	6900	4.10	trace	
8	0	6900	4.10	0	
9	0	6550	4.10	0	
10	1.4	7000	3.95	0	
11	0	7400	3.85	0	
12	0	6300	3.80	0	
13	0	7600	4.05	0	
14	0	6800	4.10	0	
15	0	7200	4.10	0	
16	0	7600	4.10	0	
17	0	8300	4.15	0	
18	0	7000	4.00	0	
19	0	8000	4.20	0	
20	0	7750	4.05	0	
21	0	7700	4.10	0	
22	0	7650	4.05	0	
23	0	7650	4.05	0	
24	0.4	8550	4.00	0	
25	0	8000	4.00	0	
26	0	7050	4.05	0	
27	0	7450	4.10	0	
28	0	8350	4.00	0	
29	0	7300	4.10	0	
30	0	7300	4.10	0	
31	0	7600	4.10	0	
Total	16.0	213,210		100	

TABLE 3-12 (Cont'd)

LEACHATE FROM COAL WASTE AND LOW GRADE COAL PILES

DATE	RAIN	COALY WASTE		LOW GRADE COAL	
AUG 1979	mm	VOLUME ml	pH	VOLUME ml	pH
1	0	7800	4.10	0	
2	0	8300	4.10	0	
3	8.6	7400	4.10	0	
4	0	8300	4.10	0	
5	0	8800	4.00	0	
6	Trace	8400	4.10	0	
7	0	8800	4.00	0	
8	0	8200	4.00	0	
9	0	8000	4.00	0	
10	0	8300	4.00	0	
11	0	8000	4.00	0	
12	0	8400	4.00	0	
13	0	8600	3.95	0	
14	1.2	8750	4.00	0	
15	0.2	8850	4.00	0	
16	2.2	7900	4.00	0	
17	1.0	8900	4.05	0	
18	0	8650	4.05	0	
19	2.0	9400	4.05	0	
20	0	9000	4.05	0	
21	1.0	8000	4.00	0	
22	0	8800	4.00	0	
23	Trace	8450	4.05	0	
24	5.8	9300	4.05	0	
25	20.8	8450	4.00	0	
26	0	+1700	4.00	>12,500	3.90
27	0	8450	4.00	3,750	3.90
28	0	8550	4.00	1,700	3.90
29	0	8350	4.05	1,000	3.95
30	0	9000	4.00	650	3.85
31	0	8800	4.05	600	3.90
Total	42.8	+256,600 +Overflow		> 20,200 > Overflow	

TABLE 3-12 (Cont'd)

LEACHATE FROM COAL WASTE AND LOW GRADE COAL PILES

DATE	RAIN	COALY WASTE		LOW GRADE COAL	
SEPT. 1979	mm	VOLUME ml	pH	VOLUME ml	pH
1	0	8950	4.00	500	3.90
2	0	6900	4.00	350	3.90
3	0	9550	4.00	200	3.90
4	0	7900	4.00	120	3.90
5	0	8400	4.00	100	3.90
6	0	8150	3.95	50	4.10
7	0	8000	4.05	30	3.95
8	12.8	8100	4.00	1900	3.90
9	0	7800	4.05	2000	3.95
10	0.6	7950	3.95	1350	3.90
11	0	7800	4.00	900	3.90
12	0	8050	4.05	700	3.85
13	0	8000	4.00	500	3.85
14	0	8150	4.00	350	3.90
15	0	8700	4.05	300	4.00
16	0	9550	4.05	250	3.95
17	0	8575	4.05	175	3.90
18	0	7900	4.05	120	3.95
19	0	8150	4.00	90	3.90
20	0	8700	4.00	90	4.00
21	0.6	8550	4.05	60	4.00
22	0	8150	3.95	40	
23	0	8050	4.05	25	
24	0	8150	4.05	5	
25	0	7600	4.00	0	
26	0	8100	4.00	0	
27	0	8000	4.05	0	
28	0	7900	4.00	0	
29	0	7900	4.05	0	
30	0	8350	4.00	0	
Total	14.0	246,025		10,205	

TABLE 3-12 (Cont'd)

LEACHATE FROM COAL WASTE AND LOW GRADE COAL PILES

DATE	RAIN	COALY WASTE		LOW GRADE COAL	
OCT 1979	mm	VOLUME ml	pH	VOLUME ml	pH
1	0	8600	4.05	0	
2	0	8400	4.05	0	
3	0	8450	4.00	0	
4	0	7750	4.00	0	
5	0	8200	4.05	0	
6	Trace	8250	4.00	0	
7	0	8250	4.05	0	
8	0	8000	4.00	0	
9	0	8150	3.90	0	
10	0	8250	4.05	0	
11	0	8000	4.05	0	
12	0	8000	4.05	0	
13	0	7700	4.05	0	
14	3.2	7400	4.05	0	
15	4.8	8200	3.90	0	
16	Trace	7650	3.90	100	3.85
17	5.2	>Flooded	-	650	3.80
18	0	8350	3.90	2250	3.80
19	0	8500	3.90	1000	3.80
20	0	7900	3.80	620	3.80
21	0	7700	3.85	500	3.90
22	Trace	7800	3.85	350	3.90
23	0	7500	3.80	250	3.90
24	3.0	7550	3.80	200	3.90
25	1.6	7550	3.80	180	3.85
26	Trace	6650	3.80	280	3.80
27	0	6900	3.80	300	3.95
28	0	7150	3.85	300	3.90
29	0	6450	3.80	170	3.70
30	0	7600	3.75	240	3.90
31	0	7750	3.75	160	3.90
Total	17.8	> 234,600		7550	

TABLE 3-12 (Cont'd)

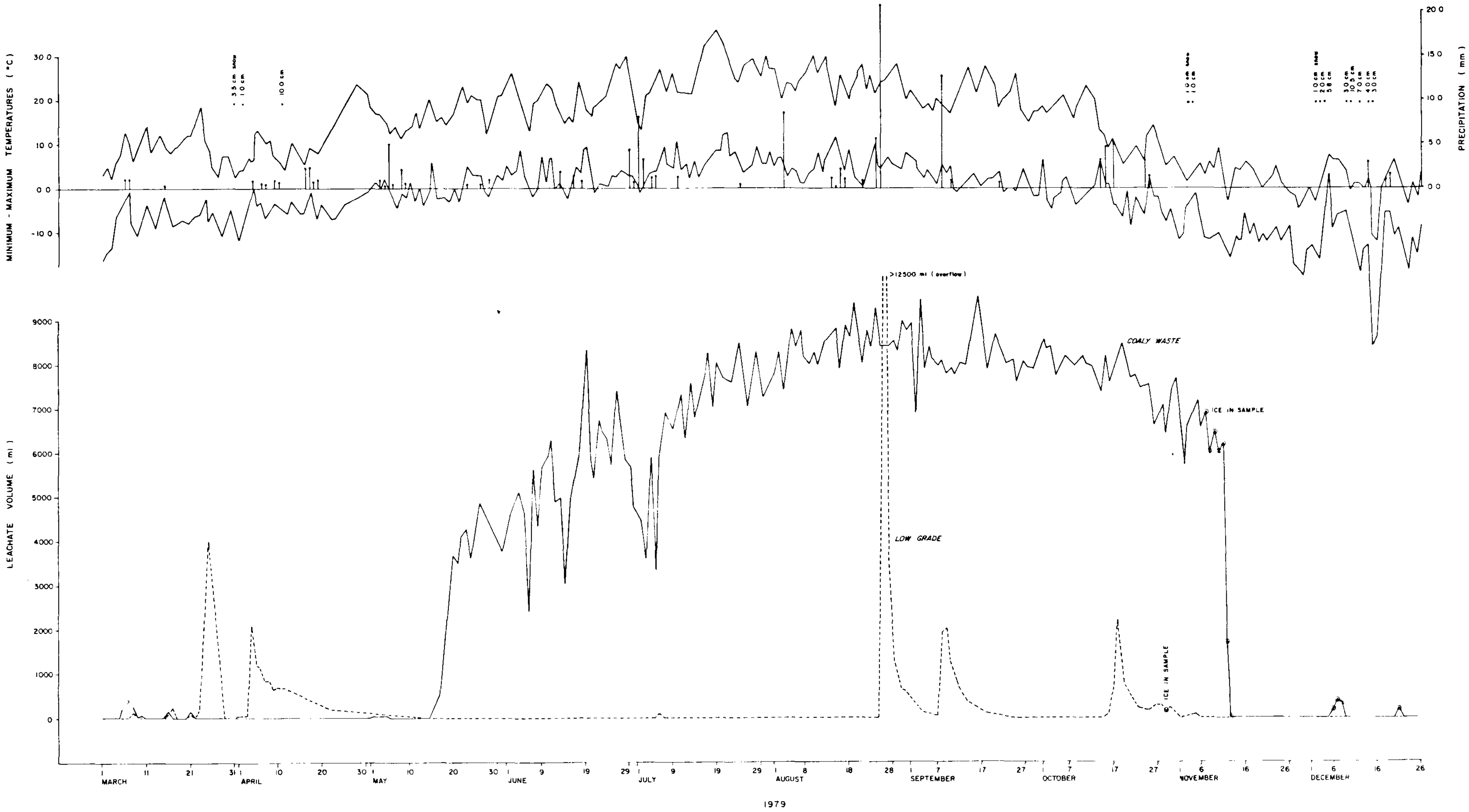
LEACHATE FROM COAL WASTE AND LOW GRADE COAL PILES

DATE	RAIN	COALY WASTE		LOW GRADE COAL	
NOV. 1979	mm	VOLUME ml	pH	VOLUME ml	pH
1	*	6100	3.75	50	4.10
2	*	5700	3.75	0	
3	*	6800	3.75	60	3.75
4	0	6900	3.80	70	3.90
5	0	7250	3.80	100	4.10
6	0	6650	3.70	5	-
7	0	+6900	3.70	0	
8	0	+6000	3.70	0	
9	0	+6500	3.45	0	
10	0	+6000	3.40	0	
11	0	+6200	3.55	0	
12	0	+1500	3.40	0	
13	0	Trace		0	
14	0	Trace		0	
15	0	Trace		0	
16	0	Trace		0	
17	*	Trace		0	
18	*	Trace		0	
19	0	Trace		0	
20	0	0		0	
21	0	0		0	
22	0	0		0	
23	0	Trace		0	
24	0	0		0	
25	0	0		0	
26	0	0		0	
27	0	0		0	
28	0	0		0	
29	0	0		0	
30	0	0		0	
Total	0.0 *Snow	+72,500 +Plus Ice		285	

TABLE 3-12 (Cont'd)

LEACHATE FROM COAL WASTE AND LOW GRADE COAL PILES

DATE	RAIN	COALY WASTE		LOW GRADE COAL	
DEC. 1979	mm	VOLUME ml	pH	VOLUME ml	pH
1	0	0		0	
2	*	0		0	
3	*	0		0	
4	*	0		0	
5	0	}		0	
6	0	}		0	
7	0	}		0	
8	0	} +950	4.05	0	
9	*	Trace		0	
10	*	0		0	
11	0	0		0	
12	*	0		0	
13	0	}		0	
14	*3.0	}		0	
15	*	}		0	
16	0	}		0	
17	Trace	}		0	
18	1.0	}		0	
19	1.6	}		0	
20	0	}		0	
21	0	} +200	5.15	0	
22	0	Trace		0	
23	*	0		0	
24	*	0		0	
25	0	0		0	
26	1.0	0		0	
27	0	0		0	
28	0	0		0	
29	0	0		0	
30	0	0		0	
31	*	0		0	
Total	6.6 *Snow	+1150 +Plus Ice		0	



HAT CREEK PROJECT
1979 ENVIRONMENTAL FIELD PROGRAM

FIGURE 3-4

LEACHATE FLOWS
TEMPERATURE AND PRECIPITATION

The results of the coaly waste and low grade leachate analyses are presented in Table 3-13 and 3-14. The coaly waste pile had lower concentrations than in 1978 for most of the parameters tested except for nickel and fluorine. The higher values for the 24 May sample are probably due to the initial total thaw releasing the leachate frozen in the pile over the winter. The low grade pile had higher levels of most of the parameters in 1979 except for nickel and arsenic. Comparison of the two piles shows that the coaly waste pile had 200 times the amount of nitrate-nitrogen as did the low grade pile. Nitrogenous fertiliser was put onto the coaly waste pile in the fall of 1978 and had probably contributed to this concentration. The coaly waste leachate was yellow while the low grade leachate was colourless. The specific conductance for both piles were within the ranges determined in 1978. Field pH tests showed acidic readings ranging from 3.8 to 4.2 in the low grade pile and from 3.5 to 4.1 in the coaly waste pile.

3.7 Hat Creek Coliform Counts

Since 1976, water samples from B.C. Hydro exploration water supply wells in the Hat Creek area have been sent to the B.C. Department of Health to check for potability. Further to these tests, a survey was begun in September 1979 to record coliform levels at two sites along Hat Creek. Fecal and total coliform counts were made to establish background levels in the creek. Samples were collected from Hat Creek near Hillman house upstream of the mine site and at Highway 12, just downstream of the mine site. These studies are to be continued. Table 3-15 shows the 1979 results.

TABLE 3-13 - SURFACE WATER - COAL WASTE LEACHATE

SURFACE WATER - COAL WASTE LEACHATE

Date of Sampling / (mg/L) Parameter Dissolved (D), Total (T) - CATIONS	28/4/78	9/6/78 Diss.	9/6/78 Total	23/8/78 Diss.	23/8/78 Total	24/5/79 Diss.	24/5/79 Total	24/8/79 Diss	24/8/79 Total	27/8/79 Diss	27/8/79 Total
Aluminum (Al)	2.9	3.4	3.3	9.7			24	8.2		7.3	
Arsenic (As)	<0.005	<0.005	<0.005	<0.005			0.007		0.007		0.008
Cadmium (Cd)							<0.005	<0.01		<0.01	
Calcium (Ca)	760	720	720	800			800	500		460	
Chromium (Cr)	<0.010	<0.010	<0.010	<0.010			<0.01	<0.02		< 0.02	
Copper (Cu)	0.034	0.034	0.034	0.044			0.025	0.016		0.012	
Iron (Fe)	0.30	0.13	0.37	0.38			0.56	0.10		0.09	
Lead (Pb)							<0.01	< 0.02		<0.02	
Lithium (Li)	0.17	0.19	0.13	0.24			0.26	0.09		0.09	
Magnesium (Mg)	580	570	570	550			550	440		420	
Mercury (Hg)(ug/l)	<0.25	<0.25	<0.25				<0.25		<0.25		<0.25
Molybdenum (Mo)							0.050	0.006		0.010	
Nickel (Ni)	0.10	0.052	0.053				0.098	0.080		0.084	
Potassium (K)	30			20			27	12		12	
Selenium (Se)	<0.003	<0.003	<0.003	<0.003			<0.003	<0.003		<0.003	
Sodium (Na)	240	190	190	190			170	130		130	
Strontium (Sr)	1.8	3.5	1.5	3.6			2.3	1.3		1.1	
Vanadium (V)	0.042	0.033	0.018	<0.04			0.23	0.020		0.018	
Zinc (Zn)	0.057	0.089	0.089	0.13			0.17	0.12		0.11	
Beryllium								<0.0003		<0.0003	
Manganese								2.4		2.2	
Uranium								0.00020		0.00010	
Thorium								0.32		0.18	

TABLE 3-13 (continued)

Parameter (mg/L) Diss. (D), Total (T) ANIONS, ORGANIC, CALCULATED VALUES / Date of Sampling	SURFACE WATER - COAL WASTE LEACHATE										
	28/4/78	9/6/78		23/8/78		24/5/79		24/8/79		27/8/79	
		Diss.	Total	Diss.	Total	Diss	Total	Diss	Total	Diss	Total
Boron (B)	0.2	0.2	0.23	0.44			0.2	0.2		0.3	
Chloride (Cl)	15		15		11	10		5.4		5.5	
Fluoride (F)			0.097		0.096	0.238		0.209		0.250	
Sulfate (SO_4)	3800		4300		2900	5600		2300		1900	
Total-Kjeldahl-Nitrogen (N)											
Nitrate-Nitrogen (NO_3 -N)						450		380		420	
Nitrite-Nitrogen (NO_2 -N)						0.090		<0.003		<0.003	
Total-Orthophosphate-Phosphorus (P)											
Dissolved-Total PO_4 Phosphorus (P)			<0.003	0.010		<0.003		<0.003		0.003	
COD											
TOC			395		430				257		290
Phenol											
Total Hardness ($CaCO_3$)	4290		4140		4261				3100		2300
Total Alkalinity ($CaCO_3$)	56		23		<0.5				<0.5		<0.5
BOD_5											
D.O.											
% Saturation											

TABLE 3-13 (continued)

Parameter / Date of Sampling PHYSICAL DATA (mg/L)	SURFACE WATER - COAL WASTE LEACHATE 28/4/78	9/6/78 Diss.	9/6/78 Total	23/8/78	24/5/79	24/8/79	27/8/79
pH (units)	5.6		5.2	4.3	4.0	4.1	3.9
Specific Conductance (μmhos/cm @ 25° C)	7100		7500	7080	6830	5490	5580
True Color (Pt-Co Units)							
Turbidity (NTU)			32	4.0		30	33
Temperature (°C)							
Total residue			9231	8097	8510		
Filtrable residue	8190		8960	8058	7210	6130	6320
Non-filtrable residue	22		271	39	1300	263	260
Fixed total residue							
Fixed filtrable residue							
Fixed non-filtrable residue							

TABLE 3-14 - SURFACE WATER - LOW GRADE COAL LEACHATE

Parameter (mg/L) Dissolved (D), Total (T) - CATIONS / Date of Sampling	28/4/7	27 / 8 / 79 Diss	27 / 8 / 79 Total	SURFACE WATER - LOW GRADE COAL LEACHATE
Aluminum (Al)	0.70	1.5		
Arsenic (As)	<0.005		<0.001	
Cadmium (Cd)		<0.01		
Calcium (Ca)	430	350		
Chromium (Cr)	<0.010	<0.02		
Copper (Cu)	0.007	<0.01		
Iron (Fe)	0.010	0.08		
Lead (Pb)	—	<0.02		
Lithium (Li)	0.36	0.30		
Magnesium (Mg)	420	690		
Mercury (Hg)(ug/l)	<0.25		<0.25	
Molybdenum (Mo)		0.005		
Nickel (Ni)	0.16	0.056		
Potassium (K)	36	24		
Selenium (Se)	<0.003	<0.003		
Sodium (Na)	150	150		
Strontium (Sr)	1.2	2.3		
Vanadium (V)	0.006	0.005		
Zinc (Zn)	0.18	0.52		
Uranium		<0.0000		
Manganese		9.0		
Beryllium		<0.0003		
Thorium		0.18		

TABLE 3-14 (continued)

(mg/L) Parameter Diss. (D), Total (T) ANIONS, ORGANIC, CALCULATED VALUES / Date of Sampling	28/4/7	27/8/79	SURFACE WATER - LOW GRADE COAL LEACHATE																		
Boron (B)	0.7	2.3																			
Chloride (Cl)	0.88	1.5																			
Fluoride (F)		0.131																			
Sulfate (SO_4)	3800	4300																			
Total-Kjeldahl-Nitrogen (N)																					
Nitrate-Nitrogen (NO_3 -N)		2.0																			
Nitrite-Nitrogen (NO_2 -N)		0.003																			
Total-Orthophosphate-Phosphorus (P)																					
Dissolved-Total PO_4 Phosphorus (P)		0.019																			
COD																					
TOC		9																			
Phenol																					
Total Hardness($CaCO_3$)	2800	3700																			
Total Alkalinity($CaCO_3$)	<0.5	<0.5																			
BOD_5																					
D.O.																					
% Saturation																					

TABLE 3-14 (continued)

Parameter \ Date of Sampling PHYSICAL DATA (mg/L)	28/4/78	27/8/79	SURFACE WATER - LOW GRADE COAL LEACHATE																		
pH (units)	4.6	3.9																			
Specific Conductance (μmhos/cm @ 25° C)	4630	5650																			
True Color (Pt-Co Units)																					
Turbidity (NTU)		33																			
Temperature (°C)																					
Total residue																					
Filtrable residue	5400	6970																			
Non-filtrable residue	3	166																			
Fixed total residue																					
Fixed filtrable residue																					
Fixed non-filtrable residue																					

TABLE 3-15

COLIFORM TESTING - HAT CREEK

1979	HAT CREEK AT HILLMAN HOUSE		HAT CREEK AT HIGHWAY 12		WELL WATER AT HAT CREEK EXPLORATION OFFICE
	TOTAL COLIFORM MPN/100 ml	FECAL COLIFORM MPN/100 ml	TOTAL COLIFORM MPN/100 ml	FECAL COLIFORM MPN/100 ml	TOTAL COLIFORM MPN/100 ml
September 19	33	8	79	79	<2.2
October 14	79	49	27	8	<2.2
November 19	16	16	16	16	<2.2

Provincial and international standards recommend that drinking water should be completely free of organisms. The results indicate some coliform bacteria contamination in Hat Creek, thus the water should not be used for a drinking water supply unless it is treated. The levels of coliform and fecal coliform bacteria in Hat Creek are typical of small streams in agricultural areas. The well sample from near the B.C. Hydro exploration trailer showed no coliform contamination.

4.0 AIR QUALITY MONITORING

4.1 Suspended Particulates

A network of six high-volume air samplers was established in 1977 to monitor ambient air suspended particulate levels in the Hat Creek region. Suspended particulate monitoring was continued during 1978 and 1979 at five of the six monitoring stations to provide additional background information.

The locations of the monitoring stations are as follows: Station Number 1 is located along Highway 12, about 10 km from the mine site. Station Number 2 is located at the junction of the Hat Creek Road and Highway 12, near the project office. Station Number 3 was located on top of the pump house at the Hydro camp trailer. This station was abandoned in 1978 as it was installed for use during the Bulk Sample Program which was completed. Station Number 4 is located in Upper Hat Creek at the Milner Ranch. The weather trailer about 3 km from the mine site is the location of Station Number 5. Station Number 6 is located in Cache Creek.

The results of the 1979 suspended particulate monitoring programme are presented in Table 4-1 and 4-2. Annual geometric means for 1978 and 1979 included data from an entire year but in 1977 only data for the months April to December were included.

In 1979 the data recovery was 81.2% slightly lower than the 86.6% recovery achieved during 1978. The average suspended particulate levels at all stations increased in 1979 compared to the 1978 results. Overall the average levels recorded in 1978 were 88 percent higher. This was probably due to the low levels

TABLE 4-1

HAT CREEK PROJECT ENVIRONMENTAL PROGRAMME

AMBIENT AIR QUALITY MONITORING

24-Hour Suspended Particulate Concentrations (Hi-Volume Sampler) in $\mu g/m^3$

1979	STATION 1	2	3	4	5	6
Jan. 3	*	3		7	*	*
9	*	*		7	*	*
15	*	*		6	7	*
21	4	4		3	2	*
27	8	11		6	6	*
Feb. 2	16	8		6	24	*
8	8	4		5	4	*
14	11	44		7	5	*
20	17	2		3	*	*
26	15	16		16	*	*
Mar. 4	18	18		17	*	79
10	16	19		20	14	*
16	17	28		19	12	87
22	10	*		11	6	67
28	11	12		21	10	87
Apr 3	8	9		18	5	44
9	4	4		7	3	25
15	16	7		8	4	27
21	8	19		*	8	34
27	18	26		*	36	76
May 3	37	10		*	8	68
9	13	12		*	*	30
15	21	38		*	21	115
21	*	36		29	6	60
27	41	32		15	19	32
June 2	11	*		*	*	*
8	15	49		33	14	58
14	15	24		26	31	40
20	15	15		20	65	50
26	44	30		37	33	77

1979	STATION 1	2	3	4	5	6
July 2	8	*		9	4	48
8	7	11		10	7	*
14	*	11		10	16	42
20	19	*		36	*	71
26	22	*		32	*	76
Aug. 1	*	71		*	31	68
7	*	27		20	13	60
13	37	98		59	28	73
19	10	11		9	7	30
25	8	*		*	8	48
31	*	*		59	13	70
Sept 6	8	27		22	9	19
12	9	23		18	10	116
18	20	45		40	20	36
24	*	51		27	27	*
30	8	9		10	5	*
Oct. 6	13	27		38	22	*
12	*	53		40	25	132
18	7	7		9	9	52
24	7	11		8	9	60
30	*	20		16	9	109
Nov. 5	*	21		19	12	123
11	*	22		13	12	91
17	*	9		6	6	67
23	13	19		8	6	80
29	17	40		16	10	146
Dec. 5	3	2		12	2	36
11	2	3		5	5	68
17	6	2		2	2	24
23	4	3		3	5	42
29	4	3		3	3	*

* = NO DATA

	1	2	3	4	5	6
TOTAL NO. OF OBSERVATIONS	61	61		61	61	61
TOTAL NO. OF VALID OBSERVATIONS	47	52		53	52	44
MAXIMUM 24-HOUR CONCENTRATION	44	98		59	65	146
GEOMETRIC MEAN CONCENTRATION	11.2	14.1		12.6	9.5	57.7

TABLE 4-2

AMBIENT AIR QUALITY MONITORING

Summary of 1977 to 1979 24-Hour Suspended Particulate Concentrations (Hi-Volume Sampler)

STATION NO. and YEAR		NO. OF VALID OBSERVATIONS (% of Total)	Number of Observations in Range (Data in μg/m³)											GEOMETRIC MEAN μg/m³
			0-20	21-40	41-60	61-80	81-100	101-120	121-140	141-160	>150	161-200	>200	
1	1977	38 (73)	33	5										9.2
	1978	57 (93)	55	3										8.4
	1979	47 (77)	41	4	2									11.2
2	1977	36 (67)	19	6	7	3			1					21.0
	1978	58 (95)	43	13	2									11.4
	1979	52 (85)	31	14	5	1	1							14.1
3	1977	23 (50)	14	7	2									17.2
	1978	Discontinued												
4	1977	33 (79)	28	5										9.6
	1978	53 (87)	47	3	2	1								6.6
	1979	53 (87)	39	12	2									12.6
5	1977	22 (96)	21	1										7.6
	1978	51 (84)	46	4		1								8.6
	1979	52 (85)	41	10		1								9.5
6	1977	35 (70)	5	14	8	4	3	1						37.3
	1978	45 (74)	6	17	10	5	5		1			1		40.7
	1979	44 (72)	1	10	11	13	3	3	2	1				57.7

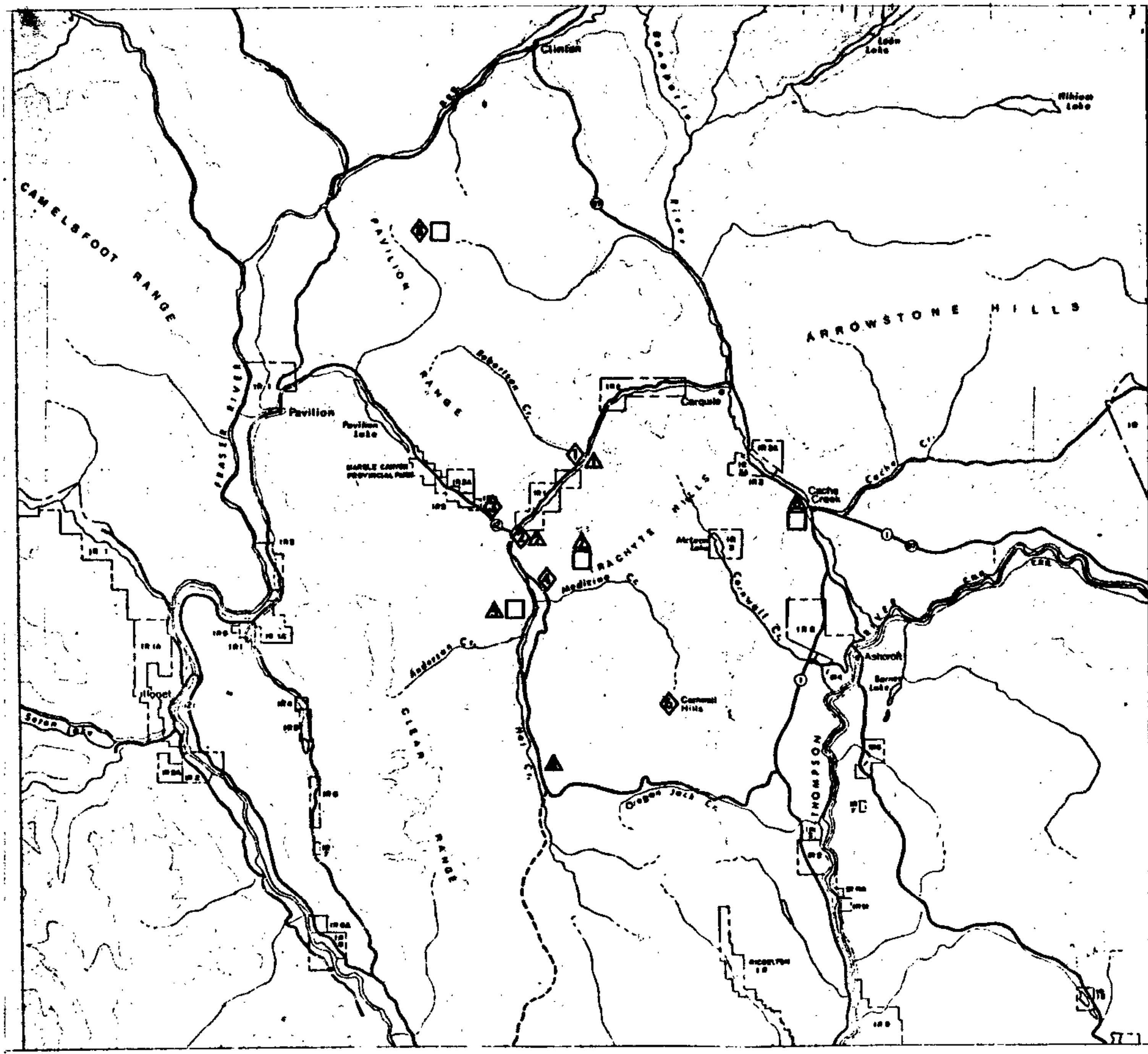
Station 1 - Highway 12
Station 2 - Valley Junction
Station 3 - B.C. Hydro Camp
Station 4 - Milner Ranch
Station 5 - Weather Trailer
Station 6 - B.C. Hydro District Office, Cache Creek

of precipitation, 251 mm (9.9 inches), that occurred during 1979. During 1979 the Waste Management Branch (WMB) (formerly Pollution Control Branch (PCB)) 24-hour average objective of 150 $\mu g/m^3$ and the annual geometric mean objective of 60 $\mu g/m^3$ were met at all monitoring stations. At most stations suspended particulate levels were very low. At the B.C. Hydro District Office in Cache Creek the annual geometric mean of 57.7 $\mu g/m^3$ was only slightly below the provincial ambient objective. However, this value may have been somewhat biased as no data were obtained during January and February when suspended particulate levels tend to be relatively low.

4.2 Weather Stations

In 1974 eight weather stations were established in the Hat Creek area to continuously monitor, wind run, wind direction, temperature and humidity. The locations of these eight stations are shown in Figure 4-1. The station coordinates and elevations and a complete list of the parameters monitored are given in Table 4-3.

During 1979 data collection was continued at most of these stations. Station No. 5 at the airstrip was shutdown in October 1977. Stations nos. 4,7 and 8 were shut down in May 1979. These weather parameters are also monitored at the plant site, valley trailer and mobile air quality stations. This data is being reduced and put into computer storage by the Environmental Services Section, Operations Group.



SCALE - 1:250,000

0 Kilometres 5 10 15

CONTOUR INTERVAL - 250 METRES

BRITISH COLUMBIA
HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT
METEOROLOGICAL & AIR QUALITY MONITORING STATIONS

LEGEND

- ◇ *Meteorological stations*
- △ *High volume sampler stations*
- □ *Air quality monitoring stations*

FIG. 4-1

TABLE 4-3 - B. C. HYDRO METEOROLOGICAL AND AIR QUALITY STATIONS

NO.	STATION NUMBER	STATION NAME	LATITUDE °	LATITUDE '	LONGITUDE °	LONGITUDE '	ELEVATION m	PERIOD OF RECORD BEGIN YR MO	PERIOD OF RECORD END YR MO	HOURLY WEATHER	CLIMATE REPORT	TEMP-DRY BULB	TEMP-DEW POINT	TEMP-DIFF.	HUMIDITY	PRECIPITATION	RATE/RAINFALL	WIND-DIR.-SPD	WIND-BIVANE	WIND-U.V.W.	VISIBILITY	PRESSURE-BARO.	SUNSHINE	EVAPORATION	SNOW COURSE	SO_2	O_3	NO_x	CO	PARTICULATE	DUSTFALL	SULPHATION	FLUORIDATION	CORROSION
	HAT CREEK - METEOROLOGICAL																																	
1	116531	Highway 12	50	50	121	33	760	1974 11		X		X			X			X																
								1977 04																						X				
								1979 07																							X	X		X
								1979 08																									X	
2	116532	Junction	50	48	121	36	838	1974 11		X		X			X			X																
								1977 05																						X				
								1979 07																							X	X		X
								1979 08																									X	
3	116533	Marble Canyon	50	49	121	38	853	1974 11		X		X			X			X																
								1979 07																							X	X		X
								1979 08																									X	
4	116534		50	46	121	35	960	1974 11	1979 05	X		X			X			X																
								1979 07																							X	X		X
								1979 08																									X	
5	116535	Airstrip	50	45	121	37	1006	1974 11	1977 10	X		X			X			X																
6	116536	Cornwall Mountain	50	45	121	27	2027	1975 03		X		X			X			X																
								1977 01																	X									
								1979 07																							X	X		X
								1979 08																									X	
7	116537	Trachyte Hills	50	47	121	32	1408	1974 12	1979 05	X		X			X			X																
								1978 02	1978 07	X		X	X			X																		
8	116538	Pavilion Mountain	50	59	121	42	2088	1975 02	1979 05	X		X			X			X																
								1977 11		X		X			X			X																
								1979 08																							X	X	X	X
	116541	Hygrothermograph A	51	45	121	35	969	1974 12	1975 03	X		X			X																			
	116542	Hygrothermograph B	51	46	121	34	1067	1974 12	1975 03	X		X			X																			
	116543	Hygrothermograph C	51	46	121	34	1195	1974 12	1975 03	X		X			X																			
	116544	Hygrothermograph D	51	46	121	33	1295	1974 12	1975 03	X		X			X																			
	116545	Hat Creek Climate Station	50	45	121	35	899	1974 11		X	X	X			X	X																		
	HAT CREEK - AIR QUALITY TRAILERS																																	
	1	Plant Site	50	47	121	32	1460	1978 07		X		X	X	X		X	X																	
								1978 08														X												
								1979 07																							X	X		X
								1979 08																									X	
								1979 09																X										
		10m Tower	50	47	121	32	1470	1978 07		X		X	X																					
								1978 08		X								X																
		100m Tower	50	47	121	32	1560	1978 07		X		X	X					X																
	2	Valley Trailer	50	45	121	36	975	1977 08		X		X	X					X			X									X				
								1977 10		X																	X	X						
								1977 11		X						X										X								
								1978 07		X													X											
								1979 07																							X	X		X
								1979 08																									X	
	3	Mobile	50	49	121	20	466	1977 05																						X				
								1977 08		X		X	X					X			X													
								1977 10		X																X	X	X	X					
								1979 07																								X		X
								1979 08																							X		X	
	HAT CREEK - MISCELLANEOUS																																	
		A. Parke's Ranch						1976 07	1977 11	X		X	X										X											
		Merry Lake	50	47	121	33	1372	1977 04																	X									
		Hydro Camp						1977 05	1977 11																					X				
		Milner's Ranch						1977 04																						X				
		Pavilion	50	55	121	49	1235	1978 01																	X									

4.3 Ambient Air Characteristics

In 1977 a programme was initiated to measure physical and chemical characteristics of the ambient air in the vicinity of Hat Creek. Four monitoring locations were established; the valley station is located at weather station No. 5, shown in Figure 4-1; the mobile station is located in Cache Creek in the Hydro yard; the mountain station is located atop Pavillion Mountain at weather station No. 8; and the plant station is located at weather station No. 7, shown in Figure 4-1. A 100 m tower is located at the plant station and some variables are measured both at ground level or 10 m and at 100 m.

The variables monitored at these locations are shown in Table 4-3. The results of this detailed monitoring are reported to B.C. Hydro monthly by Western Research and Development.

Precipitation data collected at the I. Lehman ranch during 1979 are presented in Table 4-4.

TABLE 4-4 - PRECIPITATION AT HAT CREEK AS MEASURED AT I. LEHMAN RESIDENCE

MONTH (1979)	RAIN (mm)	SNOW (cm)
JANUARY	0	42.0
FEBRUARY	0	11.0
MARCH	2.2	3.5
APRIL	9.6	10.5
MAY	11.2	0
JUNE	9.4	0
JULY	16.0	0
AUGUST	42.8	0
SEPTEMBER	14.0	0
OCTOBER	17.8	0
NOVEMBER	0	2
DECEMBER	6.6	53.3
TOTAL:	129.6	122.3
TOTAL PRECIPITATION: 251.9 mm.		

5.0 ENVIRONMENTAL TRACE ELEMENT STUDIES

5.1 Introduction

In October 1976 a study was conducted to determine trace element concentrations naturally present in the terrestrial and aquatic environments in the vicinity of Hat Creek. Seven materials were analysed including: water, sediments and fish at two locations in Hat Creek and at two locations in the Bonaparte River: and soils, shrubs, grasses, lichen and small mammals at five terrestrial sites. This study was conducted for B.C. Hydro by Environmental Research and Technology, Inc. (ERT) Santa Barbara, California,[6] In the October 1976 survey three samples of each material were collected from the sampling sites. In January and May 1977 single samples of each material were collected from the sampling sites.

The results of the 1976 and 1977 studies are reported by ERT in the report entitled "Air Quality and Climate Effects of the Proposed Hat Creek Project, Appendix F, The Influence of the Project on Trace Elements in the Ecosystem", document P-507-F-F, July 1978.[6] Most of the analyses showed normal levels of trace elements in the Hat Creek receptors tested. However, the concentrations of some elements, particularly fluorine and tin, were found to be considerably greater than the levels normally present in natural environments. The ERT report contained no explanation of these exceptional results but did recommend that additional studies be conducted to provide additional data to enable the design of a valid trace element monitoring programme.

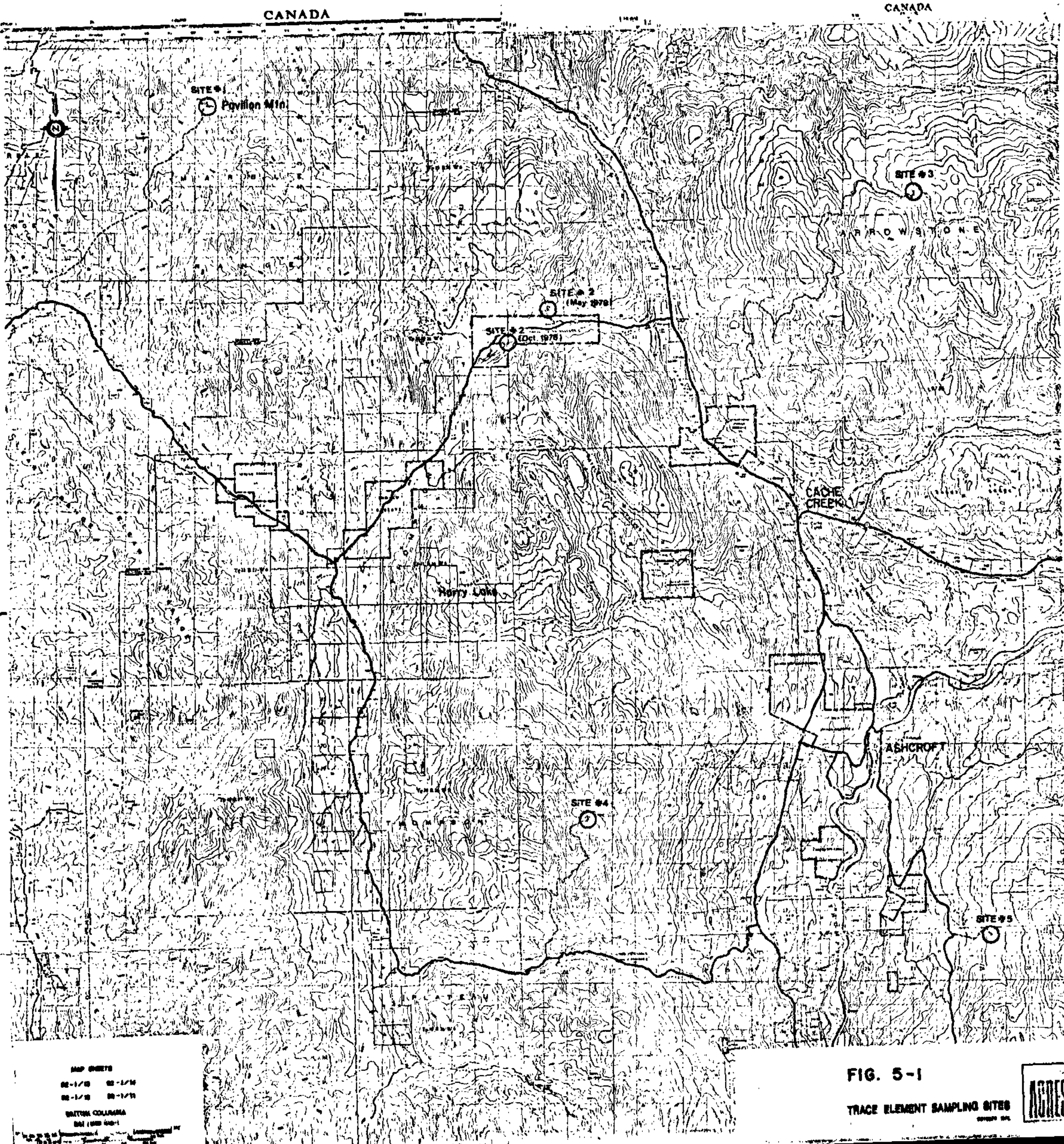


FIG. 5-1

TRACE ELEMENT SAMPLING SITES

ACRES

In October 1978 further trace element studies were conducted to provide additional data and to verify the earlier data. These results have been reported in the 1978 Environmental Field Programmes report.

In May 1979, Acres Consulting Services Limited were retained by B.C. Hydro to collect samples from the five terrestrial sampling sites established by ERT. Samples of soils, shrubs, grasses and lichen were collected. The aquatic sites were not sampled because the terrestrial sites showed the greatest variations and considerable data has been developed on surface water quality in Hat Creek and the Bonaparte River. Small mammals were not sampled because of the difficulty in obtaining samples. The samples were prepared and analysed by Chemex Labs Ltd., North Vancouver.

A description of the May 1979 sampling programme and a brief discussion of the results are presented in this section of the report.

5.2 Sampling Sites

The five terrestrial sampling sites established and described by ERT are as follows:

Site Number	Name	Elevation (feet)	Slope (degrees)	Aspect
1	Pavilion Mountain	6,853	20 to 25	SE
2	Lower Hat Creek	2,460	10	W
3	Arrowstone Creek	4,920	20	WSW
4	Cornwall Mountain	6,678	10	NW
5	Ashcroft	4,150	10 to 20	W

The exact locations of these sites were not specified by ERT, however, approximate locations were indicated on a 1:250,000 map. It was not possible to identify any of the original 100 m^2 sites, therefore new sites, which closely approximate the above conditions, were selected during the 1978 sampling programme. These sites were marked with a metal stake which had yellow tape or a yellow flag on it.

The locations of the Ashcroft and Lower Hat Creek sample sites have been slightly modified in the May 1979 sampling programme. The sampling sites, which are indicated in Figure 5-1 can be reached as follows:

Site #1 - Pavilion Mountain

Follow Highway 12 west from Highway 97 until just past Pavilion Lake. Turn right at Milkranch Creek onto a dirt road that goes through an Indian reserve. This road is maintained by B.C. Telephone Company for the microwave station. Just past the station, follow the southeast fork in the road to the end, approximately 800 metres. These roads are not indicated on the government topographical maps but are shown on the map included in this report. Photo 1 illustrates the typical vegetative cover at the site.

PHOTO 1

Site #2 - Lower Hat Creek

A new location for the sampling site was selected for the Lower Hat Creek trace element studies. This site more closely approximates the conditions as described by ERT. In addition, the new location offers easier access.

The sampling site can be reached as follows: Follow Highway 12 west from Highway 97 to the gravel pit located at 1.6 kilometers from the eastern end of Bonaparte Indian reserve #2. A dirt road to the north is located at this point. Follow this road through the gravel pit and up a hill until an elevation of 2460' (725m) is reached. From here walk in a north east direction up the side slope to an elevation of 750m. The sampling site is identified by 3 stakes marked with yellow flagging. This site has a slope of 10 - 15° with 220° south west facing aspect. This site is shown in Photo 2.

PHOTO 2

Site #3 - Arrowstone Creek

Follow Highway 97 north from Cache Creek to Bonaparte Indian Reserve #3A. Turn right (north east) onto a gravel road about halfway through the reserve. Follow this road (which is indicated as a "cart track" on the government topographical map) past the transformer station to a very sharp curve in the road at a road elevation of 4,850 feet. There is also a forest service marker on a tree on the east side of the road at this point. From this point on the road the site is about 200 metres to the northwest.

Site #4 - Cornwall Mountain

This location can be reached from the Hat Creek site or from Highway 1 just south of Ashcroft. The road is gravel and well maintained as there is a forest lookout station at the top. The sample site is about 50 to 75 metres southwest of the lookout. This site which faces northwest is shown in Photo 3.

PHOTO 3

Site #5 - Ashcroft

The Ashcroft sampling site has been relocated. The new site can be reached as follows: Follow paved road south from Ashcroft about 12 km. At this point there is a gravel pit on the northeast side of the road and a sharp bend in the paved road. Follow this dirt road for a distance of 2.0 to 2.5 km (from gate). The roadside elevation should be approximately 4250' (1265m). Yellow flagging on several trees at this point indicate the direction to walk in towards the sample site. Walk in a south easterly direction (follow the yellow flagging) about 200 - 300 m. A small creek must be crossed in order to reach the sample site which is marked by a stake with yellow flagging. The sampling site is located in the same general area as last years location and has identical slope, aspect and elevation characteristics, i.e. Aspect 275° N; Slope 10°.

Sample Collection

Samples were collected from Site #1 on May 28, 1979, from Sites #2 and #4 on May 29, from Site #3 on May 30 and from site #5 on May 31. The weather conditions at the different sampling sites were as follows:

Site #1	-	Snow flurries and strong wind. Lightning.
Site #2	-	Sunny and warm with the occasional light shower.
Site #3	-	Sunny and warm with a slight breeze.
Site #4 and #5	-	Sunny with cloudy periods & a warm breeze.

Three samples of each material (grass, willow, lichen and soil) were collected at each site, except at the Cornwall Mountain site where no grass samples were collected. Due to the northwest facing aspect of this sampling site there was much snow cover in the area and grass was unavailable for sample collection.

The sampling locations at each site were chosen in a random manner by using a random numbers chart to determine direction from a central point. Initially, random distances from the central point were to be utilised, however, due to the low abundance of the lichen and willow specimens, this method could not be employed. All samples were collected along a random direction in degrees from magnetic north until sufficient quantities were accumulated. The distance from the central points ranged from 1 to 30 metres depending on sample availability.

Central points are marked with metal stakes with a yellow tape. At three sites (Pavilion Mountain, Cornwall Mountain and Arrowstone Creek), fluorescent purple stakes were driven into the ground in order to assist in location of the random directions. These spikes are located within 4 to 6 metres of the central stake and are not indicators of random distances.

The sampler, wearing plastic gloves and using acid-washed (10% HNO_3) stainless steel scissors, clipped the vegetative samples. Grass was cut 3 to 5 cm above the soil; willow was sampled by cutting ends of branches less than 30 cm in length. Lichens were picked from trees.

As much as possible (up to 200 g) of each sample was collected. However, it was not possible in some areas to collect the specified 200 g due to time and/or a low abundance of the specimen. Samples were placed directly into labelled white paper bags then double bagged and sent to Vancouver to be analysed.

Soil samples were collected from the top 5 cm using an acid-washed stainless steel knife and plastic trowel. A minimum of 200 g of each soil sample was collected. Soil samples were placed into labelled, heavy plastic bags and sent to B.C. Hydro, Vancouver, B.C. Different species of shrub willow were noted in the five sites. No attempt was made to identify and segregate the species. The samples collected probably included more than one species. Shrub willow at the Cornwall Mountain and Pavilion Mountain sites exhibited buds while at the three lower elevation sites the willows had leaves. Willow plants at the Pavilion Mountain site are shown in Photo 5.

PHOTO 5

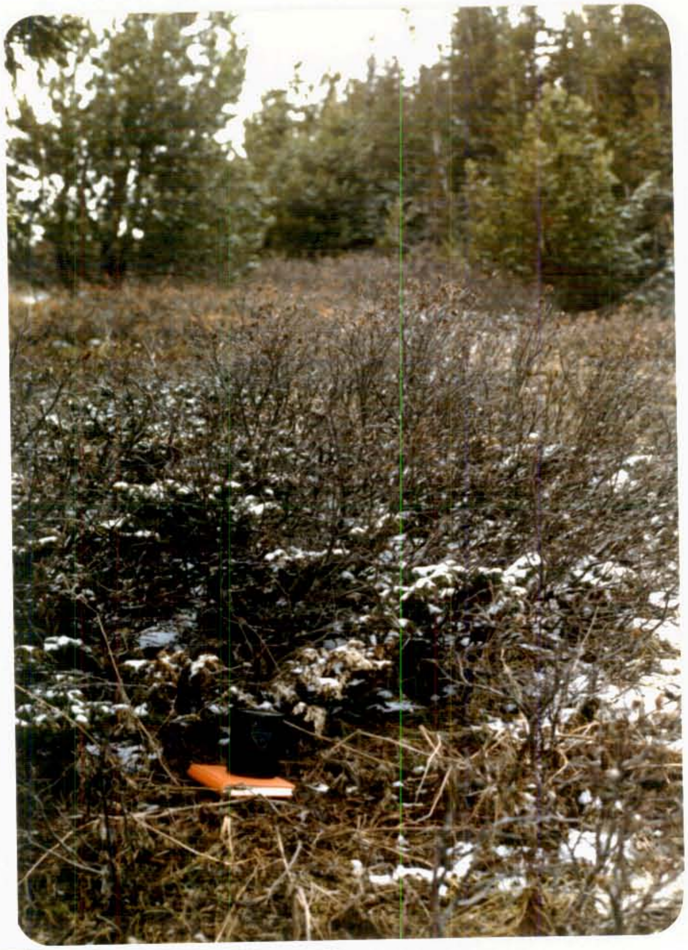


PHOTO 6

At the higher elevation sites it was not possible to be absolutely certain of the identification of the Bluebunch Wheatgrass. At this time of year the grasses are dormant and only at the Lower Hat Creek location (Site #2) was positive identification made. Grass samples from the other sites may be a composite of grass species. A typical grass sample collection site is shown in Photo 6.

Lichen samples were collected from trees as shown in Photo 7.

PHOTO 7

5.4 Analytical Results and Discussion

The same analytical techniques were used in 1979 as in 1978. The results of the trace element analyses are shown in Table 5-1 to 5-4. The values in columns 1,2, and 3 represent, in most cases, the average of duplicate analyses for the three samples of each material collected. Blind triplicate analyses are reported in the triplicate columns (i.e. 1/2/2/2/3/4/5).

In 1979 the concentrations of most of the trace elements in each of the four materials were similar to the levels found in 1978. The 1979, chromium and fluorine concentrations were slightly lower and copper slightly higher in the grass samples.

In the lichens mercury was the only element that showed a decrease in concentration. The results of the willow analyses show that fluorine levels were lower in 1979. There were lower levels of boron in the soils in 1979 than in 1978.

Overall, these differences were small and the values were all within the normal range found in natural environments.

A number of 1978 samples were reanalysed for quality control in the 1979 testing. Results are shown in Table 5-5. With the exception of mercury, the agreement between 1978 and 1979 values for the 1978 samples is good.

TABLE 5 - 1 - HAT CREEK TRACE ELEMENT ANALYSES - GRASSES

Element mg/kg	PAVILION MOUNTAIN							CORNWALL MOUNTAIN		
	1	1	1	2	3	4	5	1/2/3	4	5
As	0.8	0.5	0.5	0.5	-	<0.5	<0.5	-*	0.23	<0.5
Be	0.02	0.03	0.02	0.02	-	<0.17	0.022	-	<0.17	0.0375
B	10.95	12.95	13.25	9.05	14.0	2.67	7.47	-	5.0	22.1
Cd	<0.1	<0.1	<0.1	<0.1	-	<0.27	<0.1	-	<0.3	0.85
Cr	0.6	1.0	0.6	(17.5)	-	3.67	2.1	-	<1.1	6.45
Co	<0.08	<0.08	0.10	<0.08	-	<0.23	<0.05	-	<0.2	0.25
Cu	3.5	4.0	3.5	5.0	-	5.33	2.7	-	4.67	3.5
F	1.9	2.4	2.2	2.0	1.9	29	<10	-	14	<10
Fe	135	95	142.5	145	-	102	79.3	-	152	352
Pb	1.0	2.0	1.5	2.0	-	<4	<1	-	<4	<1.3
Hg	0.035	0.06	0.1	0.05	0.075	0.19	0.11	-	0.12	0.14
Mo	<1	<1	1	1	-	5	<1	-	4	<1
Se	<0.2	<0.2	<0.2	<0.2	-	<2.23	<0.2	-	<0.93	<0.2
Sr	15.0	18.0	16.5	18.5	-	19.0	16.7	-	13.3	7.4
Sn	<1	<1	<1	<1	-	10.3	<1	-	23.7	<1
U	<0.1	<0.1	<0.1	<0.1	<0.1	<0.87	<0.1	-	<0.83	<0.1
V	<0.8	<0.8	0.8	0.8	-	0.43	0.47	-	0.8	0.5
Zn	21.5	29.5	19.0	19.0	-	20.7	37.3	-	35.7	104.0

Element mg/kg	ARROWSTONE CREEK					LOWER HAT CREEK †					ASHCROFT †				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
As	<0.5	<0.5	<0.5	0.4	<0.5	0.8	0.5	0.5	<1.83	<0.5	-	0.5	0.5	0.33	<0.5
Be	0.02	0.02	0.02	<0.02	0.022	0.02	0.03	0.02	<0.23	0.023	-	0.02	0.02	<0.2	0.027
B	4.7	5.25	5.05	2.33	5.1	7.15	8.4	7.9	3.0	13.24	9.2	8.45	7.55	2.33	16.4
Cd	<0.1	<0.1	<0.1	<0.3	<0.1	<0.1	<0.1	<0.1	<0.33	<0.1	-	0.1	0.1	<0.37	<0.1
Cr	1.0	0.8	0.9	3.67	2.4	0.6	1.9	0.7	8.33	3.76	-	0.8	0.65	6.67	1.47
Co	0.08	0.14	0.12	<0.27	<0.5	0.08	0.14	0.10	<0.53	<0.12	-	<0.08	<0.08	<0.3	<0.04
Cu	7.5	6.0	5.5	6.33	3.0	5.0	5.0	5.0	13.67	2.4	-	5.0	6.0	6.67	2.3
F	<1	<1	<1	22	<10	2.0	2.5	3.4	24.0	<10.0	<1.0	1.2	1.0	13.33	<10.0
Fe	147.5	115	110	230	62	112.5	200	155	208	208.6	-	60.0	60.0	210.0	51.3
Pb	3.5	2.0	1.0	<4	<1	1	1	1.5	<21.7	1.2	-	1.0	1.5	<4	<1
Hg	0.1	0.075	0.095	0.18	0.09	0.09	0.025	0.05	0.12	0.07	0.06	0.06	0.06	0.08	0.07
Mo	4	3	3	6.33	<1.6	1	2	2	11	<1	-	4.5	3.5	4.33	2.17
Se	<0.2	<0.2	<0.2	<3.33	<0.2	0.2	0.6	0.3	<2.3	<0.2	-	<0.2	<0.2	<6.67	<0.2
Sr	28.0	24.5	24.5	19.0	39.3	30.5	37.5	44.5	45.7	67.8	-	23	19.5	27.3	30
Sn	<1	<1	<1	31.0	<1	<1	<1	<1	131	<1	-	<1	<1	161	<1
U	<0.1	<0.1	<0.1	<1.3	<0.1	<0.1	<0.1	<0.1	<1.33	<0.1	<0.1	<0.1	<0.1	<1.67	<0.1
V	0.8	0.8	0.8	<0.27	0.73	<0.8	0.8	0.8	1.6	1.36	-	0.8	0.8	0.67	0.6
Zn	23.0	27.0	21.0	14.0	21.0	26	22	26.5	23.3	20.2	-	22	25.5	16.7	17

Column 5 1978 average
Column 4 1976 average
* No grass on site
† New Sampling location
() Data in brackets suspect

TABLE 5-2 - HAT CREEK TRACE ELEMENT ANALYSES - LICHENS

Element mg/kg	PAVILION MOUNTAIN 1	2	3	4	5	CORNWALL MOUNTAIN 1	2	3	4	5
As	0.5	1.5	1.5	0.63	0.58	1.5	1.5	1.3	0.93	0.67
Be	0.03	0.03	0.02	<0.2	0.032	0.03	0.03	0.03	<0.2	0.047
B	10.45	7.75	5.1	1.57	5.83	3.25	5.0	5.05	1.83	3.57
Cd	0.3	0.3	0.3	<0.33	<0.1	0.2	0.3	0.7	<0.3	0.25
Cr	1.3	2.1	1.6	5.67	1.92	2.3	2.3	2.2	5.0	2.37
Co	0.26	0.46	0.34	<1.2	0.33	0.4	0.42	0.52	2.0	0.37
Cu	4.5	5.0	5.0	12.0	4.0	4.5	5.0	3.0	16.33	2.33
F	2.9	6.6	4.7	16.0	<10.0	6.5	8.8	6.7	46.67	<10.0
Fe	393	625	510	573	475	780	890	620	387	703
Pb	16	19.5	13.5	29.33	17.83	21	23.5	13.5	14.67	21.83
Hg	0.46	0.65	0.50	0.58	1.35	0.50	0.60	0.58	0.56	1.69
Mo	<1	1	<1	4.7	<1	<1	<1	1	8	<1
Se	<0.2	0.2	<0.2	<1.07	<0.2	0.2	0.2	<0.2	<0.67	<0.2
Sr	6.5	6	6	14.3	7.17	3	4.5	6	19	6
Sn	<1	1	<1	>381	<1	1	<1	<1	305	<1
U	<0.1	<0.1	<0.1	<1	<0.1	<0.1	<0.1	<0.1	<1	<0.1
V	1.6	2.8	2.0	2.33	1.8	2.8	3.6	2.4	3.0	2.6
Zn	29	33	32	25.3	30.33	29	31.5	39.5	57.7	41
SO_4	1300	1350	1150	-	2100	1650	1550	1400	-	2383

Element mg/kg	ARROWSTONE CREEK 1	2	3	3	3	4	5
As	0.5	<0.5	<0.5	0.5	0.5	1.2	0.58
Be	0.02	0.02	0.02	0.02	0.02	<0.2	0.045
B	6.8	8.45	4.65	5.2	5.45	2.57	5.5
Cd	0.1	0.1	0.1	0.1	0.1	<0.33	0.1
Cr	NSS	1.2	1.8	1.8	1.4	11.33	1.58
Co	NSS	0.2	0.32	0.26	0.34	0.93	0.34
Cu	5.5	5.5	6.0	7.0	6.5	8.67	7.0
F	3.2	3.0	4.1	4.6	4.3	49.0	<10
Fe	290	320	485	550	470	593	432
Pb	12.5	11.5	14.5	17.0	15.5	17.67	14
Hg	0.34	0.44	0.55	0.46	0.45	0.48	1.44
Mo	1	2	1	<1	<1	4.3	<1
Se	<0.2	<0.2	<0.2	<0.2	<0.2	<1.17	<0.2
Sr	8.5	8.5	10.0	10.5	10.5	46	12.83
Sn	<1	<1	<1	<1	<1	>354	<1
U	<0.1	<0.1	<0.1	<0.1	<0.1	<0.97	<0.1
V	1.2	1.6	2.4	2.8	2.4	3.67	2.27
Zn	31.5	32.5	38.5	37.5	35.0	55.3	35.67
SO_4	NSS	1150	1450	1600	1600	-	1933

Element mg/kg	LOWER HAT CREEK † 1	2	3	4	5	ASHCROFT † 1	2	3	4	5
As	1.5	1.0	2.0	1.57	0.5	1.5	2.0	1.5	0.73	0.92
Be	0.04	0.03	0.06	<0.23	0.051	0.02	0.02	0.02	<0.2	0.04
B	11.05	4.75	4.45	1.8	12.82	6.45	5.2	7.75	2.27	4.4
Cd	0.15	0.2	<0.1	<0.4	<0.1	0.3	0.3	0.2	<0.33	0.1
Cr	3.9	4.5	3.4	9.67	4.53	1.9	1.3	1.3	7	2.63
Co	0.58	0.64	0.46	1.83	0.5	0.36	0.32	0.36	<1.57	0.34
Cu	16	15.5	18.5	9.67	7.2	19	23	22	32.33	22.67
F	8.1	10.8	13.3	157	<10	4.4	4.2	4.3	52	<10
Fe	1150	1450	1600	570	789	408	485	532.5	443	434
Pb	29	31	35	53.33	21.8	17.5	21.5	15.5	36.67	19.67
Hg	0.45	0.46	0.45	0.25	0.67	0.35	0.41	0.45	0.47	1.02
Mo	1	1	1	5.7	<1	1	1	<1	4.3	<1
Se	0.2	0.3	0.2	<1.47	<0.2	0.2	0.2	<0.2	<1.1	<0.2
Sr	14.5	17	13	29	9.2	11.5	10	20.5	23.7	8.6
Sn	<1	<1	<1	51	<1	<1	1	<1	239	<1
U	<0.1	<0.1	<0.1	<1.33	<0.1	<0.1	<0.1	<0.1	<1.67	<0.1
V	4.8	6.0	6.8	6	4.48	3.2	2.0	3.2	2.33	2.73
Zn	39	39	37.5	31	28.6	34.5	31.5	32.5	67	24
SO_4	2650	2500	2500	-	2140	1900	1900	1700	-	2483

Column 5 1978 average
Column 4 1976 average
NSS Not sufficient sample
† New sampling location

TABLE 5-3 - HAT CREEK TRACE ELEMENT ANALYSES - SHRUBS

Element mg/kg	PAVILION MOUNTAIN					CORNWALL MOUNTAIN					ARROWSTONE CREEK				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
As	0.5	0.5	<0.5	<0.6	<0.5	1.0	0.5	0.5	<0.6	0.5	<0.5	<0.5	<0.5	<0.37	<0.5
Be	0.03	0.01	0.03	<0.13	0.028	0.03	0.02	0.03	<0.17	0.027	0.02	0.02	0.02	<0.17	0.013
B	20.45	14.3	15.5	10.67	13.9	19.05	16.1	19.35	16.67	15.36	10.9	15.6	15.6	46.67	14.73
Cd	1.45	1.9	1.1	<0.87	1.78	3.8	2.3	3.7	<0.83	4.24	<0.1	0.1	<0.1	<0.3	<0.1
Cr	0.8	0.9	0.9	2.0	1.17	0.5	0.6	0.6	3.33	1.17	0.7	0.6	0.6	9	1.05
Co	0.24	0.20	0.22	0.43	0.21	0.4	0.18	<0.08	0.93	0.28	0.18	0.28	0.08	4	<0.053
Cu	5.5	4	6	100	7	5	5	4.5	10.67	4.2	6	6.5	6	14.33	5.33
F	1.5	1.1	1.3	263	<10	1.4	1.5	1.4	707	<10	<1.1	1.2	1.2	78	<10
Fe	62.5	62.5	55	123	140	80	115	72.5	141	132	57.5	60	40	87	92
Pb	1	1	<1	5.67	1.67	<1	1	<1	<3.0	1.8	1	1	1.5	<3	3
Hg	0.04	0.055	0.03	0.07	0.075	0.065	0.06	0.07	0.05	0.083	0.04	0.085	0.06	0.04	0.11
Mo	<1	1	<1	5	<1	1	<1	<1	6.67	<1	3.5	2.5	3	<5	<1
Se	<0.2	<0.2	<0.2	<0.4	<0.2	<0.2	<0.2	<0.2	0.40	<0.2	<0.2	<0.2	<0.2	<0.43	<0.2
Sr	33.5	23.5	21.5	26.33	31.17	10.5	6	7	44.33	13.2	56.5	46	52	87	21.5
Sn	1	1	<1	345	<1	<1	<1	<1	399	<1	<1	<1	<1	61.33	<1
U	<0.1	<0.1	<0.1	<0.7	<0.1	<0.1	<0.1	<0.1	<0.63	<0.1	<0.1	<0.1	<0.1	<0.93	<0.1
V	<0.8	<0.8	0.8	0.27	0.6	<0.8	0.8	0.8	0.37	0.6	0.8	0.8	0.8	0.43	0.67
Zn	127	123	77	187	147.7	112	101	115	313	139.2	34	76.5	52.5	69	9.67

Element mg/kg	LOWER HAT CREEK †							ASHCROFT †				
	1	2	2	2	3	4	5	1	2	3	4	5
As	0.8	0.5	0.5	0.5	<0.5	<0.97	<0.5	0.5	0.5	0.5	<0.47	<0.5
Be	0.03	0.02	0.02	0.02	0.02	<0.1	0.025	0.02	0.02	0.01	<0.1	0.023
B	21.0	23.1	21.75	22.85	21.05	11.67	18.77	24.4	23.7	26.55	111	21.6
Cd	0.1	<0.1	<0.1	<0.1	0.1	<0.33	<0.13	<0.1	0.1	<0.1	<0.47	<0.35
Cr	0.65	0.95	0.8	0.8	0.65	1.67	1.07	0.8	0.6	0.5	6	0.85
Co	<0.08	<0.08	<0.08	<0.08	<0.08	3.93	<0.06	0.08	0.08	<0.08	1.43	<0.04
Cu	7	8	8	8	8	31.33	6.5	7	7	6	21.33	7
F	<1	1.1	<1	1.1	<1.1	111	<10	<1	<1	<1	115	<10
Fe	57.5	55	50	50	55	57	125	60	62.5	62.5	138	77
Pb	<1	1	<1	<1	1	10	3.5	1.5	1	1.5	5	2.83
Hg	0.06	0.025	0.03	0.035	0.04	0.1	0.092	0.04	0.04	0.02	0.1	0.077
Mo	<1	1	1	1	1	4	<1	1	4	2	5	<1
Se	0.08	0.08	1.1	0.95	0.35	<0.3	<0.2	<0.2	<0.2	<0.2	<0.43	<0.2
Sr	160	198	192	168	172	102	104.7	18.5	17	16.5	273	21.5
Sn	<1	<1	<1	<1	<1	833	<1	<1	1	<1	25.33	<1
U	<0.1	<0.1	<0.1	<0.1	<0.1	<0.6	<0.1	<0.1	<0.1	<0.1	<0.77	<0.1
V	0.8	0.8	0.8	0.8	0.8	<0.17	0.67	<0.8	0.8	0.8	0.27	0.8
Zn	45.5	34	34.5	35.5	36	157	53	16	12	16	383	37

Column 5 1978 Average
Column 4 1976 Average
† New Sampling Location

TABLE 5-4 - HAT CREEK TRACE ELEMENT ANALYSES - SOILS

Element mg/kg	PAVILION MOUNTAIN					CORNWALL MOUNTAIN						
	1	2	3	4	5	1	1	1	2	3	4	5
As	-	3.0	2.5	4.33	2.93	4.3	5.8	6.0	5.5	5.0	5.0	5.32
Be	-	0.6	0.5	0.53	1.05	0.3	0.4	0.45	0.3	1.3	<0.33	0.76
B	5.95	6.9	7.05	6.33	11.43	9.45	10.5	8.95	8.4	2.3	11.7	8.58
Cd	-	1.3	0.5	<0.57	0.47	6.3	5.3	6.3	1.6	1.6	<1.13	2.68
Cr	-	81	74.5	88.3	130.7	41.5	49	51	36.5	80.5	82.7	66.6
Co	-	15	14	13.3	11.83	8	9	10	5	10.5	10.7	4.9
Cu	-	25	27	40.3	28.33	21	24	26	20	26	34.3	19.2
F	57.5	100	70	217	195	107.5	120	95	445	322.5	222	125.2
Fe	-	2.28	2.15	>0.1	3.44	1.15	1.55	1.58	1.2	2.4	>0.1	1.15
Pb	-	6	6	10	6.33	9	10	12	18	16	11.3	(250)
Hg	0.11	0.16	0.16	0.16	0.12	0.17	0.15	0.14	<0.3	0.09	0.09	0.077
Mo	-	1	1	3	<1	2	2.5	2	2	1.5	5.0	<1
Se	-	<1	<1	<2.97	<1	<1	<1	<1	<1	<1	<1.27	<1
Sr	-	147.5	147.5	483	157	90	87.5	90	72.5	145	207	92.2
Sn	-	<1	1	337	<1	<1	<1	<1	<1	1	5.33	<1
U	<0.5	2.25	0.5	<4.33	<0.5	0.5	0.5	0.5	<0.5	0.75	<3.67	<0.5
V	-	97.5	92.5	387	148	50	65	60	50	110	194	50
Zn	-	139	121	116	132	206	196	205	196	163	220	136

Element mg/kg	ARROWSTONE CREEK					LOWER HAT CREEK †					ASHCROFT †				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
As	2.5	2.0	2.0	3.0	1.1	7.8	10.5	8.5	8.33	7.3	6	4	4.25	3.67	3.
Be	1.4	1.05	1.65	0.3	1.65	1.45	1.5	1.6	0.43	1.85	1.05	0.9	1.15	<0.43	1.
B	2.2	2.65	2.55	3.0	5.83	5.0	4.95	6.25	15	16.83	4.8	3.45	3.85	8.67	10.
Cd	<0.1	<0.1	<0.1	<0.33	0.12	0.1	0.2	0.2	<0.43	0.12	0.25	0.2	0.1	<0.43	0.
Cr	69	80	78	530	106	146	173	154	154	136	123	111	117	380	12
Co	13	13	16	21.3	8.33	23.5	28	25.5	12	16.83	13	12.5	12	7.3	9.
Cu	18	18	34	37.7	16.67	50	54	48	58.3	55.7	20	20	20	65	27.
F	152.5	172.5	192.5	43.7	185	270	335	258	467	356	195	207.5	217.5	89	24
Fe	2.23	1.85	3.15	>0.1	1.98	4.8	5.18	4.75	>0.1	4.82	2.23	2.13	2.40	>0.1	2.
Pb	10	8	10	4	6.5	12	13	13	7.7	9	6	6	4	5.7	3.
Hg	0.02	<0.1	<0.01	0.07	0.055	0.12	0.05	0.01	0.07	0.058	<0.01	0.03	0.03	0.04	0.
Mo	2	1	1	2.33	<1	1.5	1	1.5	3	<1	<1	1	1	1	<1
Se	<1	<1	<1	2.33	<1	<1	<1	<1	2	<1	<1	<1	<1	2.33	<1
Sr	210	277.5	230	547	267	65	62.5	52.5	233	187	327.5	335	328	400	27
Sn	1	1	1	23.3	<1	1	1	1	24.3	<1	1	1	1	35.7	<1
U	<0.5	0.5	1.75	<3.0	<0.5	0.75	0.5	1.25	4.33	<0.5	0.5	0.5	0.5	<2.67	<0.
V	90	80	125	377	94	195	197.5	195	278	184	137.5	132.5	125	253	114
Zn	121	60	101	226	76	137	142	140	92	144	143	145	110	82	15

Column 5 1978 Average
Column 4 1976 Average
† New Sampling Location
() Data in brackets suspect

The 1979 mercury levels in the 1978 lichen samples were consistently lower than the levels determined last year. A series of checks were instituted: testing the National Bureau of Standards (NBS) Orchard Leaves, adding a spike to a sample before digestion, and repeating analyses for several samples. Results are presented in Table 5-6. Because of the good replication, the complete spike recovery, and the excellent NBS values obtained, the new mercury levels for the 1978 lichen samples appears to be correct. The lower values obtained this year most likely reflect volatility losses from the powerdered samples over the year in storage.

TABLE 5-5 - QUALITY CONTROL RESULTS *

SAMPLE NUMBER	SAMPLE	1979 Sn mg/kg	1979 F mg/kg	1979 Hg µg/kg	1979 B mg/kg	1979 U mg/kg	1978 Sn mg/kg	1978 F mg/kg	1978 Kg µg/kg	1978 B mg/kg	1978 U mg/kg
78-15	SOIL	1	1	70	16.3	0.1	1	10	50	16.3	0.1
-16		1	1	70			1	10	65		
-28	WILLOW	1			18.7		1			14.8	
-32		1	1	50		0.1	1	10	100		0.1
-33			9.0	50				10	60		
-43		1			6.5	0.1	1			4.6	0.1
-48	LICHEN		6.2	310	15.4	0.1		10	900	11.9	0.1
-51			2.4	310				10	500		
NBS ORCHARD LEAVES:											
ACTUAL				150							
CERTIFIED				155±15							

TABLE 5-6 - MERCURY LEVELS IN LICHEN SAMPLES *

SAMPLE NO.	1979 - µg/kg	1978 - µg/kg
78 - 39	560	2200
- 43	480	1100
- 48	310, 370, 380, 300, 310	900
- 48 (+200 ppb SPIKE)	560, 570	-
- 51	240, 230	520
NBS 1571	150, 150, 150	(certified value 155±15)

* *Samples collected and analysed in 1978 and reanalysed in 1979.*

6.0 REFERENCES

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6. ERT, Air Quality and Climate Effects of the Proposed Hat Creek Project, Appendix F, The Influence of the Project on Trace Elements in the Ecosystem, Document P 507-F-F, July 1978.